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UNIT – II

LESSON - 2.4

CULTURE OF GIANT FRESHWATER PRAWN
Macrobrachium resenbergii

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2.4.1. OBJECTIVE:

To know the requirements and the feasibility of culture of freshwater prawn *Macrobrachium rosenbergii.*

2.4.2. INTRODUCTION:

About a dozen species of fresh water prawns belonging to the genus *Macrobrachium* inhabit the Indian rivers and constitute a rich resource in terms of delicious protein food both for the rich and the poor. At least, three species, viz., *M. rosenbergii*, *M.malcolmsonii* and *M. birmanicum* choprai attain sufficiently large sizes and are economically very important. Of these, *M. rosenbergii*, which is the largest prawn in the world attaining over 300 mm in length and 400 g in weight, and popularly known as scampi or the giant long-legged prawn, is now cultivated on a large scale in Asia, particularly Thailand, Vietnam, Taiwan and Bangladesh, and also Latin America. In India, juveniles of various species of fresh water prawns were traditionally collected from nature and consumed either in fresh or dried condition or used as poultry feed. In some cases, these were also stocked in ponds and tanks in the near vicinity for further growth and harvested, when marketable. However, systematic aquaculture of *Macrobrachium* spp. was unknown till about two decades ago as sources of reliable seed supply did not exist. Hence, researches on development of technology for their culture were initiated only recently once the seed productioin technology was perfected and hatcheries established. In India successful larval rearing of M. rosenbergii was first achieved in 1975.

While *Macrobrachium rosenbergii* grows faster than *Macrobrachium malcomsonii*, the former has the disadvantage in having a larger cephalothoran & a smaller tail. The larger size of the male in *M.rosengergii* is a great disadvantage for markets where only tails are preferred though it is certainly advantageous where live (or) head on prawns are preferred.

Classification:

Phylum	-	**Arthropoda**
Sub phylum	-	**Mandibulata**
Class	-	**Crustacea**
Order	-	**Decapoda**
Genus	-	***Macrobrachium***
Species	-	*Rosenbergii*

2.4.3. GENERAL BIOLOGY & LIFE HISTORY:

A. BIOLOGY:

About 100 species of fresh water prawn are found all over the world, of which 25 have inhabited the Indian waters. *Macrobrachium rosenbergii* is the largest freshwater prawn in the world growing upto 31 cm in size. Its distribution is limited to the estuarine and freshwater zones of river mouths and back water (0 to 20% salinity and 25-30^0 C temperature) in the tropical and sub-tropical countries of indopacific region. Because of its fast growth, attractive size and better meat quality, the species is quite suited for monoculture or polyculture with fish in freshwater pond systems. Successful larval rearing was achieved for the first time in sixties by Dr.S.W. Ling in Malaysia. This species was later transported to USA (Hawai), Japan etc., and reared successfully. At present *Macrobrachium* farming is well developed in Thailand, Taiwan, Hawai, Mexico and Brazil. This has attracted attention all over the world and in several Asian countries including India, successful rearing has been achieved and techniques are standardized under controlled conditions.

B. SPECIES IDENTITY:

This species belongs to family Palaemonidae (under Natantia, Macrura in Decapod Crustacea) characterized by the overlapping of the pleura of second abdominal segment over those of first and third segments. *M. rosenbergii* can easily be identified by its large second pair of thoracic legs in male and its rostrum, which is sightly pinkish in colour with a double curvature and the teeth formula of 12-13 / 11-13. There are distinct black bands on the dorsal side at the junction of all the abdominal segments. In the juvenils, on the lateral sides of the carapace several horizontal black bands are characteristic of this species. However, they disappear as the juveniles grow into subadults.

C. FOOD HABITS:

This species is a bottom feeder and omnivorous. It accepts a variety of food items ranging from grains, worms, flesh pieces of mollusks, crustaceans and fish and cooked egg pieces. When the prawn is soft after moulting, other prawns irrespective of sizes predate it upon. It eats its own moult and eggs. Hence, it is necessary to provide shades and shelters for protecting themselves during moulting during culture.

D. GROWTH:

Like other crustaceans, the growth is not continous because of the hard exoskeleton covering the entire body and appendages. Growth in volume takes place during every ecdysis (moult) occurring at frequent intervals of time depending upon food and climate. The inter–moult period gradually increases with age and in the fully-grown adults, the growth stops leading to senility and death. Fully-grown adults have greenish mat of periphyton growing on the cephalothorax (head) which indicates that the growth has stopped and hence needs harvesting in pond culture operations. The species grows to maturity in about 4 to 5 months under pond conditions.

E HABITS:

The species is nocturnal in habit and most of its life activities especially moulting and hatching take place during night hours. During daytime, it is sluggish and tries to hide in the bottom. There is a tendency to establish territory and protect the same in the adults. The species locates its feed mostly by touch with feelers. Food is not completely eaten because of territorial attitude and hence feeds with a higher water stability and attractability are suitable and are recommended to be placed in pails at corners. This will help to assess consumption from the left over feed. The first pair of chelipeds is the chief organs of food capture and is assisted by the second pair. Although the species eats variety of vegetable products, it is important to provide animal feeds such as cooked meat of snails, beef etc., to prevent mortality due to cannibalism in culture practices.

F. SEXUALITY:

Males are bigger than females. In the male, the cephalothorax is bigger in size and the abdominal part narrower. The second pair of chelate legs are longer in male than female indicating sexual dimorphism. In juveniles, males can be distinguished from the females by the presence of appendix masculine additionally on the endopod of the second abdominal appendage (pleopod), like in other Palaemonids. The males are some times referred as bulls. Depending on the length of claws and size of males, three types are recognized in culture (I) Small male – claws are smaller than body length (II) Orange clawed male – claws are smaller to little longer than body size (III) Blue clawed male – claws are 1.5 to 2 times bigger than the body size – also called terminal males – better to harvest them.

Females are smaller in size with a smaller head and a broader abdominal space to serve as a brood chamber for the incubation of eggs. As many as six types can be seen in culture (i) immature –

carapace without any traces of gonad (ii) maturing – gonad under carapace gradually increases in size and colour from orange to brick red (iii) berried – fertilized eggs in the brood – pouch (iv) spent – brood pouch empty with hair like structures (v) re-maturing – gonad developing under carapace without eggs in the brood – pouch (vi) re-maturing and berried – brood pouch with eggs and gonad well developed under carapace – indicating continuous breeding and sign of excellent pond management. In the male, the genital pore is in between the bases of fifth walking legs, while that of the female is at the base of the third walking legs.

G. MATURITY:

The species grows to maturity in 6 to 9 months when their sizes are around 150mm (25g) in females and 175 mm (35g) in males. Maturity can be obtained earlier under better brood stock management. In the female, gonadal maturity can be clearly seen through the head when the orange coloured ovary gradually develops and occupies most of the cephalothorax. A small male can impregnate four to five females at a time. Breeding season differs in different river systems, but for hatchery operations, best results in larval rearing can be obtained when the water temperature is in the range of 24 to 32^0 C (optimum 27 +/-1^{0}C) with minimum variation between day and night temperatures. Mature adults occur mostly in the freshwater areas of estuaries, backwaters and lakes where there is a tidal effect from the sea. Both, mating and incubation take place in freshwater and brackishwater as the species especially females in berry are migratory in habit. Although hatching can take place in freshwater, larval survival and growth take place only in brackishwater environment in shallow canals. In this habitat, they spend their time like plankton till they are transformed into postlarvae/juveniles and become benthic in habit. Then they return back to freshwaters to grow into adults. The species can be cultured in freshwater ponds as well as slightly saline brackishwater ponds as it can tolerate salinity upto about 15 ppt during its life history.

H. BREEDING:

Female, when fully ripe is dull, shy and prefers corners. It becomes receptive to male when it is in soft condition only after moult and is zealously guarded by the male with its long pincers. This is called premating of puberty moult. Mating is only for a short time when the male deposits the sperms near the genital pore of the female located at the base of the third pair of thoracic legs. After a short time, as the eggs are extruded, they got fertilized externally. The eggs are deposited into brood chambers under the adbdomen between the pleoponds. The eggs are held together by tuft-like ovigerous setae developed for this purpose.

I. INCUBATION:

The females continuously incubate the eggs and provide sufficient aeration for the developing eggs by constantly fanning the pleopods. Depending upon temperature, the incubation period lasts from 15 to 24 (19 to 20 days at 25-32° C).

J. LIFE HISTORY AND BEHAVIOUR:

Details of life history and behaviour of the freshwater prawn *M. rosenbergii* have been given by Ling (1962) New and Singholka (1982) and Uno and Soo (1969). The life cycle of the species consists of eggs, larvae (zoea), post-larva, juvenile, sub-adult and adult (Fig. 2-14). In nature, juvenile to adult stages are spent in freshwater habitat. Maturity, mating, egg-laying and part of incubation take place in freshwater habitat and the species migrates to suitable brackishwater environment for hatching and growth of larvae through eleven stages till they are transformed into post-larvae and later juveniles. The juveniles assend into the freshwater zones of the rivers, backwaters, lakes, cannals, etc.,which receive the tidal influence. Larval stages are planktonic while post-larvae to adult stages are benethic in habit.

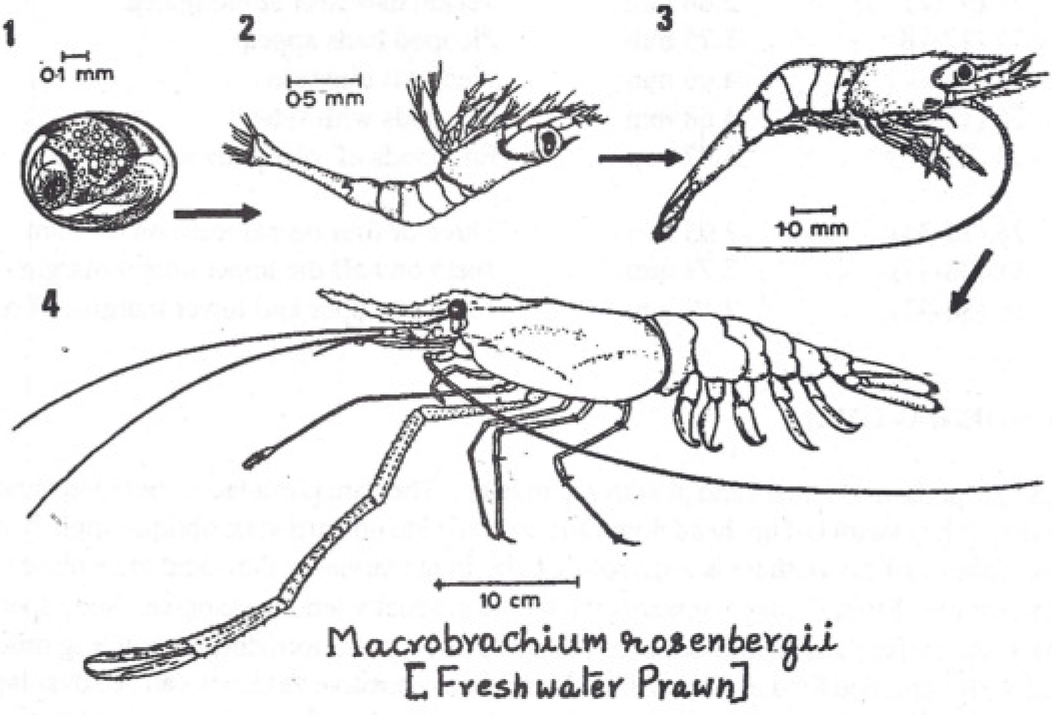

Fig. 2-14. Life cycle 1) Egg. 2) Larva 3) Post-larva 4) Adult

K. EGGS:

These are slightly oval in shape measuring 0.6 – 0.7 mm on its along axis and are bright orange in colour. Sufficient aeration is given by fanning pleopods constantly. The first pair of thoracic legs carefully removes dead eggs and foreign matter. From about 12th day onwards, a light grey colour slowly develops in place of orange colour. The gray colour deepens gradually and becomes slatish. In the females in berry with eggs about to hatch, the developing eye can been seen as a black spot. Normally, hatching takes place in about 19 days at temperature of 26-28° C.

L. LARVA:

There are eleven zoeal stages in the larval cycle of the species lasting from 30 to 45 days depending upon temperature, water quality and food. Identification characters, size and number of days (at 28° C for each stage) are given below for determining the stages and monitoring feed grades and their frequency.

Stage	Age (No.of days	Body length	Prominent character
I	0 (1-2)	1.92 mm	Sessile eyes
II	2 (2-3)	1.99 mm	Stalked eyes
III	4 (3-5)	2.14 mm	Uropods appear
IV	7 (5-9)	2.50 mm	Two dorsal teeth on rostrum
V	10 (9-12)	2.80 mm	Telson narrower & elongated
VI	14 (12-18)	3.75 mm	Pleopod buds appear
VII	17 (15-20)	4.06 mm	Pleopods biramous
VIII	20 (18-22)	4.68 mm	Pleopods with setae
IX	24 (21-29)	6.07 mm	Endopods of pleopods with appendix interna
X	28 (25-34)	7.05 mm	Three or four dorsal teeth on rostrum
XI	31 (28-37)	7.73 mm	Teeth on half the upper dorsal margin
PL	36 (36-43)	7.69 mm	Teeth on upper and lower margins of rostrum

M. LARVAL BEHAVIOUR:

These are active swimmers and planktonic in habit. They are phototactic, but direct and strong light is avoided. They swim tail up, head down and ventral side upward at an oblique angle backward. Upto 5th stage (about 10 days), there is a schooling habit in the larvae as they tend to be close together and move in swarms. From 6th stage onwards the larvae gradually tend to disperse. They spend most of their time at the surface and in mid-column, but settle down to bottom during moulting time. They actively feed on the supplied food in suspension. Their photo –positive tendency can be advantageously utilised for cleaning, feeding and water changing by partially shading the rearing containers in hatchery operations.

N. POST-LARVA:

Post-larva settles to the bottom and becomes benthic in habit. Behaviourally, it is similar to juvenile except for the under development of body parts like setae, spines teeth etc. Within a few moults, the post-larvae become juvenile. In hatchery operations, the post-larvae are gradullay conditioned from brackishwater to freshwater by continuous changes of water lasting for a day. They are transparent and can be observed by a flashlight at nights. Post-larva after acclamatisation to freshwater (ready to transport) can be called 'seed'. No such notations like PL 1 to PL 20 (popular in Tiger hatcheries) are used in *Macrobrachium* hatcheries as metamorphosis (transformation) from larvae stage XI to P.L. extends up to 20 or even 30 days due to management factors.

O. JUVENILES:

These are crawlers and settle to bottom or cling to the sides. There are 6 to 8 horizontal black bands prominently situated on the carapace at this stage. As the juveniles grow into sub-adults (about 70 to 80 mm), these bands start disappearing. In nature, the juveniles perform the backward migration to freshwater and grow into adults. Sub-adults (80 to 150 mm) and juveniles have all the morphological characteristics of adults except maturity. In sub-adults the characteristic horizontal black bands have disappeared and have clear benthic habits unlike juveniles with migratory habits from saline to freshwater in nature.

2.4.4. ESSENTIALS OF PRAWN HATCHERY:

For the establishment of a giant freshwater prawn hatchery, the following requirements are essential.

A. SITE SELECTION:

Selection of a suitable site is one of the most important factors for the establishment of a prawn hatchery. Large-scale commercial prawn hatcheries require coastal sites having adequate supply of sea water and freshwater free from pollutants. The site should be amenable for provision of infrastructural facilities such as availability of electricity, accessibility etc. Backyard hatcheries can be established at any place where good quality of freshwater is available along with either concentrated brine solution or artificial sea water.

B. INFRASTRUCTURAL FACILITIES:

The infrastructure facilities include earthen brood-stock ponds to maintain adequate supply of brooders, water supply system, aeration system, main hatchery shed for housing brood-stock holding tanks, hatching tanks, larval rearing tanks, post-larvae holding tanks, power house, pump house, etc.

Brood-stock ponds

Continious supply of good quality brooders is one of the pre-requisites for the successful operation of a commercial hatchery. Therefore, it is essential to have brood-stock ponds located in the proximity of the hatchery complex so as to avoid rough handling and long distance transporation of brooders. The texture of the soil suitable for brood-stock ponds is sandy-clay loam, which should have pH between 6.5 to 8.0. The site should have perennial source of freshwater free from pollutants.

Water supply system

The water supply system consists of seawater intake, filtration units, storage tanks for seawater, freshwater and brackishwater (mixed water) and their distribution to various sections of the hatchery.

Sea water

Seawater should be drawn through a sub-soil filter arranged 5 to 6 feet below the sand in the intertidal zone in order to make the water free from suspended particles and turbidity. If seawater is to be drawn from surface, the water should be passed through a shore sand filter before storing into the reservoir.

Freshwater

The source of freshwater may be from a tube well or form a perennial canal.

Brackish water (Mixed water)

Supernatant water from the freshwater and seawater storage tanks are pumped into the mixing tanks so as to get the desired salinity (14 ± 2 ppt). The mixed water is treated with bleaching powder to get 10 to 15 ppm chlorine to kill the microflora and fauna. After 10 to 12 hours of chlorination (contact period), the water should be dechlorinated with sodiumthiosulphate (1ppm residual chlorine needs 7 ppm of sodium thiosulphate). The dechlorinated water is treated with 10 ppm of EDTA to eliminate the dissolved heavy metals, if any.

C. MAIN HATCHERY COMPLEX:

The main hatchery complex is a shed covered with asbestos cement sheets. The main hatchery complex consists of broodstock unit, larval rearing unit, Artemia hatching unit, post-larval rearing unit.

Brood stock Unit

This unit has provision to hold berried females and hatching of the eggs. The unit is provided with freshwater, brackish water and air supply grids of PVC all along the walls inside the shed.

Berried Females Holding Tanks

The broodstock unit consists of various size (2.0 to 10.0 ton capacity) cement tanks/plastic pools / FRP tanks to hold the berried females collected from the broodstock ponds. These tanks are housed under an asbestos roofed shed. The berried females having different stages of egg development are stocked in separate tanks. Depending on the colour of eggs, the berried females are grouped into three categories i.e (1) the prawns with orange colour eggs, (2) the prawn with brown colour eggs and (3) the prawns with grey colour eggs.

Hatching Tanks

The size of hatching tanks various from 0.5 to 1.0 ton capacity in commercial hatcheries. Normally FRP tanks are used for hatching.

Larval Rearing Unit

The larval rearing unit plays a major role in the successful operation of prawn hatchery. The larval rearing shed should be situated with a north-south orientation having large windows on eastern and western sides for proper ventilation. The hatchery should have concrete flooring with proper slope and drainage facility. The unit is provided with freshwater, brackishwater and air supply grids of PVC all along the walls inside the shed.

Prawn larvae are reared in different types and sizes of tanks made up of cement. FRP, ferro-cement, etc. Smaller hatcheries use 0.25 to 1.0 ton and commercial hatcheries use 1.0 to 5.0 ton capacity parabolic shaped or circular tanks with disc shapped bottom. The tanks are provided with aeration.

Artemia Hatching Unit

Artemia hatching unit consists 50 1 to 500 1 capacity FRP cylindro-conical jars. The conical part of the jar is translucent and the inner surface of the jar is white in colour. The jar has a lid. Aeration is provided at the centre of the cone. Above the each jar two florescent tube lights are fixed to get 1000 Lux light.

Post-larval Rearing Unit

In the hatcheries the post-larvae are generally reared in 10 to 20 ton capacity cement tank / plastic pools / FRP tanks. These tanks are roofed under asbestos side open sheds. Aeration is provided in the tanks. In the field, post-larvae are reached in hapas fixed in the earthern ponds.

2.4.5. RAISING OF BROOD STOCK:

Successful run of a prawn hatchery largely depends upon continuous supply of healthy brooders. Though nature is a good source of brooders but it is not so dependable because it is beset with lot of uncertainties. It is therefore, advisable to have the facility for raising the broodstock of giant pawns as an in built component in the hatchery complex itself.

2.4.6. COLLECTION & TRANSPORTATION OF BROODERS OF *M. ROSENBERGII*

A. COLLECTION OF BROODERS:

From natural sources

During breeding season, i.e. beginning of monsoon, a large number of berried females of different stages of giant prawn are available in the estuaries. However, their abundance in estuaries depends on the amount of rainfall. The berried females and mature males and females of giant prawn are collected by dolnets, operated against water currents during high and low tides. When the net is removed from the water, the healthy and active berried females and mature males and females are separated from the catch and put into the plastic tubs containing water from the same source from where prawns have been collected. Prawns are also caught by angling using ordinary nylon lines with barbed hooks. The favourite baits used in the angling of giant prawns are earthworms and small shrimps. Prawns caught by this method are temporarily kept in nylon net cages fixed in flowing water so as to ensure their healthy condition for transport.

From the Farm Ponds

In well-established farms, berried females of giant prawns are collected from the grow-out ponds by cast netting. Before transportation, the netted out berried females as well as mature males and female prawns are carefully removed and kept for sometime in plastic tubs containing the water of the same source.

B. TRANSPORTATION OF BROODERS:

Open containers are used for short distance transportation. However, for long distances, transportation of brooders in oxygenated plastic bags becomes necessary. A 15 liters capacity container with polythene bag containing 5 litres of water and 10 litres of oxygen, accommodates one berried female without much loss of eggs during transportation. Wide mouth plastic or aluminum tubs with polythene bags can also be used for long distance transportation. For distant places involving long hours of journey, it is advisable to transport brooders in insulated containers where the temperature can be maintained at desired level. During transport, water temperature should be kept below the optimum, i.e. at around 20⁰ C to 22⁰ C, which reduces the rate of metabolic activities of the prawn resulting in low oxygen consumption and aggressiveness during transport. This method helps in keeping the prawns in healthy condition for longer duration.

While packing for long distance transportation, the prawns are kept in perforated PVC rigid pipes of 50 mm to 75 mm diameter. The length and diameter of so as to prevent the escape of prawn from the pipe. This method of packing not only prevents the spoilage of polythene bags by the strong chelate legs and rostrum of the prawn brooders during transport but also increases their carrying capacity per unit volume of water inside the polythene bag.

2.4.7. BREEDING TECHNIQUE OF *M. ROSENBERGII*

Berried females of *M. rosenbergii* for the purpose of getting larval prawns can be obtained in two ways. One way is to collect the berried female prawns directly from the natural sources of from grow-out farm ponds or from the broodstock section of the hatchery complex. The other way of getting berried female is to collect the mature male and female prawns and breed them under controlled conditions for obtaining berried female prawns is described.

A. SELECTION OF BROODERS:

Through 5 to 6 months old *M. rosenbergii*. Of 8 to 10 g weight matures and lays egg but their egg production capacity is very low (about 5000). Therefore, use of such small size females for hatchery operation will not work out to be economical. Moreover, the seed produced from such small sized brooders will also not be of genetically improved variety. Hence, healthy, active, well pigmented, large size mature male (> 125 g) and female (>75g) prawns should be selected for breeding. The stock of such prawns can be had from nature or grow out ponds of the farm or from the broodstock ponds of the hatchery complex. The males are ready to mate at any time. They are be easily identified by their large spiny second pair of walking legs. The sexually mature females, which are ready for breeding, can be identified by the presence of orange coloured mass occupying a larger portion of the dorsal and lateral parts of the cephalothorax.

B. BREEDING TECHNIQUE:

Small size tanks of cement/FRP of 2.0 x 1.0 x 0.75m are quite convenient for the breeding of giant freshwater prawn. The tanks are filled with filtered freshwater upto the height of 0.5 m and provided with aeration. Sexually matured male and female prawns are then relased in breeding tank. In each tank, prawn brooders are released in the ratio of 1:4, i.e. one male against four females. The brooders are fed regularly with earthworms, broken rice, sweet potato or formulated pelleted feeds thrice a day. In order to hasten the moulting process of females, the water quality is maintained scrupulously. To achive this, 50% of water should be exchanged daily. Breeding process is accomplished with the pre-mating moult of the female prawns. The pre-mating usually occurs at night and is preceeded by 2-3 days of fasting and reduced activities. Within 6 hours following the moult, the female becomes receptive to mating. Soon after this male starts its courtship display lifting his head, raising its body, waving its antennae and raising and extending its long and powerful chelate-legs in an embracing gesture, accompanied by intermittent jerking movements. This display continues for 10 to 20 minutes to establish firm contact with female.

After establishing the firm contact with female, the male holds the female between its chelate legs activiely cleans the ventral portion of her thoracic shell (sterna) with other walking legs (periopods) which can be easily observed . The cleaning process takes about 10 to 15 minutes. The act ultimately culminates into final mating lasting only a few seconds in which male deposits its sperm in the form of a gelatinous mass on the female's ventral median thoracic region. The egg laying process by females takes place between 6 to 20 hours after the deposition of sperm by male. During egg laying , the tail of the female prawn bends forward to reach the ventral thoracic region . At the same time, the pleopod are extended to form a protected egg passage. The eggs are then extruded through the female genital pores into the brood chamber, first on one side and then on the other side. As the eggs are extruded, they get fertilized externally. The chamber between the 4th pair of pleopods is filled first. Subsequently, those between 3rd, 2nd and 1st pairs are also filled. The eggs are held in bundles. They appear like miniature bunch of grapes and remain covered by an extremely thin elastic membrane. The egg bundles remain adhered tightly to the ovigerous setae of the first four pairs of pleopods. The eggs are kept aerated by the vigorous movement of the pleopods.

The berried female so produced is removed after a day of egg laying and are kept in a 50 liter capacity rectangular tank which is filled with freshwater and kept constantly aerated. During this period the berried prawns are fed with suitable feed such as earthworms, mussel meat, broken rice sweet potato etc. Berried prawns are never kept hungry as otherwise they may eat her own eggs. In order to maintain optimum water quality and to avoid any fungal are bacterial disease to the egg mass, the leftover feeds is removed regularly. The process of egg development is observed regularly, particularly the change of their colour . The eggs gradually change from orange to brown and lastly into gray colour in about 15 to 24days, depending on water temperature. When grey colouration of eggs is noticed, the berried female prawns are transferred into the hatching tank.

C. HATCHING:

For hatching, berried female prawns with grey colour eggs are kept in circular or rectangular tank of 50 to 100 litre capacity. The tanks are filled with 4 to 6 ppt saline water and kept constantly aerated. Hatching of eggs takes place in day or two. The entire mass hatch out in a night or two consecutive nights. During the time of hatching, the mother prawn vibrates her pleopods rapidly at intervals to disperse the hatchlings. After complete hatching, the mother prawn is removed and the hatchiling are transferred to the rearing tanks for further development.

2.4.8. NURSERY MANAGEMENT OF POST-LARVAE OF GIANT FRESH WATER PRAWN *M. ROSENBERGII*

Nursery rearing of *Macrobrachium rosenbergii* post-larvae is an intermediate phase between the hatchery and grow-out phases. Freshly moulted post-larvae are very small in size (7-8 mm) to stock in the grow-out ponds. In order to achieve higher survival and to reduce the grow-out period an intermediate nursery phase is essentially be followed. Efficient nursery management practices have been developed to rear the highly aggressive and cannibalistic nature of *M. rosenbergii* post- larvae at higher stocking densities.

A. NURSERY TANK:

Nurseries may be in the forms of cement tanks, plastic pools, fiberglass tanks of different sizes or even a portion of earthen ponds corded off with the help of hapas. The nurseries should have proper drainage facilities to harvest the juveniles. The nurseries may be indoor or outdoor but indoor nurseries are having benefits over the outdoor ones, because environmental parameters can be easily maintained in the indoor nurseries. While selecting the nurseries, smaller tanks are chosen for easy maintenance. A nursery of 20 sq.m. to 25 sq.m. is ideal. Rectangular tanks having more length and less width are well suitable for easy observations of health, behaviour and growth of the post-larvae. The height of the tanks is kept more than 0.75 meters. If the concrete tanks are used as nurseries, they are constructed on a suitable platform so as to facilitate their easy draining.

B. PREPARATION OF TANK:

. The nursery tanks are cleaned thoroughly and filled with filtered freshwater up to a height of 0.60 m. In order to reduce the cannibalism increase the surface area and to enhance the carrying capacity, the tanks are provided with shelters. The shelters can be of hume pipes, polythene strips of 10 mm width and 0.60 m to 0.75 m length. These strips are tied with sinkers to keep them vertically in the tank. The strips are distributed uniformly in the tank cut –pieces of closed mesh net pieces can also be placed in the nurseries with the help of sinkers and floats to increase the surface area. These additional substrata helping clinging of post-larvae and provided shelter, particularly at the time of moulting. The prepared nurseries are provided with aeration.

C. STOCKING OF POST-LARVAE:

The post larvae harvested from the hatchery are thoroughly acclimatized to freshwater conditions by subjecting them to low levels of salinity in gradual steps. Before stocking in the nursery tank the temperature and PH of the tank water and post- larval holding tank water are checked. If there is any change, the post - larvae are acclimatized slowly to such changed conditions before stocking.

The stocking density depends on the rearing period and the size of juveniles to be required for the grow – out ponds. In order to get on average size of 35 to 40 mm length juveniles at a rearing period of 30 days, the post-larvae are stocked @ 2500 to 3000 per m2.

D. FEED AND FEEDING:

A wide variety of feeds are in use for the raising of post-larvae which can be fed with *Moina micrura*, cut-pieces of earthworms, mussel meat, egg custard and also pelleted feed prepared with acetes, rice bran and groundnut oil cake. Shrimp starter feeds that are easily available now a days are also used as feed for the post-larvae of the giant freshwater prawn. The feed is given @ 5 to 10% of the body weight. The feed is to be spread uniformly throughout the nursery.

E. WATER QUALITY MANAGEMENT:

Optimum water quality is maintained by daily exchange of 40 to 50% water from the tank bottom. The leftover feed is removed at regular intervals. A similar range of water quality parameters, which are maintained in the larval rearing section are followed in the nursery management practices also.

F. HARVESTING:

After attaining the desired size, the juveniles have to be harvested to stock in the grow-out ponds. For harvesting, the water level of the nursery tank is reduced to ˘ th level. The juveniles are then harvested by keeping a circular fiberglass or plastic tub near the drainpipe outside the tank. The tub is provided with suitable screen box. The height of the screen box should be higher than the tub so as to eliminate the escape of juveniles while draining out the water. The collected juveniles are kept in smaller containers having same water as is in the nursery which are futher properly aeratred for conditioning to pack and transport them to the grow-out farm ponds.

2.4.9. GROW-OUT PONDS

Rectangular ponds are desirable for freshwater prawn culture. Ponds ranging in size from 0.1 to 2.0 ha with sloping plain bottom towards one side are ideal. The depth of the pond may range between 0.75 and 1.5 m. The carp culture ponds are also suitable and freshwater and freshwater prawns can also be cultured along with carps. Sandy-silt or clayey bottom soil is desirable. Filling and draining of water through gravity is most economical. Marginal aquatic vegetation is desirable as it provides food and protection for the prawns in addition to protecting the bunds from erosion. The growth of rooted vegetation may be prevented. Harvesting is a big problem in large ponds.

A. PREPARATION:

Liming is done depending on the nature of soils. Generally lime is applied at the rate of 1000 kg / ha. The ponds are filled with water through inlets covered with mesh. The inlets are so designed that some exchange of air takes place while the water is falling in to the pond. Fertilizers are also added as in carp culture. However, the quantity of fertilizers added is generally less compared to carp culture ponds. Cow dung, single super phosphate and urea is commonly used for fertilization. Different types of hideouts such as scrap nets or palm leaves, or pigeonhole type structures or earthen pipes may be arranged in the ponds to facilitate the escape the attack of larger prawns.

B. STOCKING OF SEED:

Post-larvae of 1-4 weeks after metamorphosis may be stocked in ponds after acclimatization to the pond temperature. pH is equally critical. The optimal stocking density is 25,000 to 30,000 / ha. In circulation systems the density increased to 40,000 –50,000 / ha. In continuous culture practices a higher stocking density is maintained to get better results.

C. WATER QUALITY PARAMETERS:

The important water quality parameters are given below.

Temperature	18 – 34 0C (optimum 29 – 31 0C)
Dissolved Oxygen	5 – 8 ppm
pH	7.0 – 7.5
Hardness	< 150 ppm and above > 40 ppm
Salinity	up to 6 ppt acceptable
Total dissolved solids	300 ppm

2.4.10. FEED MANAGEMENT FOR GIANT FRESHWATER PRAWN *M. ROSENBERGII*

The larvae are zooplankton feeders, adults are omnivorous and cannibalistic in the absence of food in the pond. Scampi can be cultured alone (monoculture) and with other cultivable species of fish (polyculture). It is a quick growing species and complete its life in brackish water and freshwater. It can tolerate a salinity range upto 14 ppt. The following feeding steps are essential to promote its culture in fresh water / low saline water areas of the country. The essential management aspects are selection of quality ingredients, sources of major nutrients and their inclusion in the feed preparatrion, minor raw materials used in feeds and commonly used ingradients procurements on cheaper rates from the reliable sources.

FEEDING SHEDULE FOR PRAWN

Stage	Size of Prawn (gm)	Ration size of biomass %	Feeding frequency (No. of feedings /day)
Larvae	0.01-0.1	30-20	6-4
	0.1-1.0	20-12	5-4
Starter	1-3	12-7	5-4
	3-5	7-5	5-4
Grower –1	5-8	5-4.5	5-4
	8-12	4.5-3.5	5-4
Grower –II	12-16	3.5-3.0	4
	16-20	3.0-2.5	4
Finisher	20-25	2.5-2.0	4
	25-30	2.0	4
	>30	2.0	4
Brood stock	-	1-3	2

MANAGEMENT GUIDE LINES

- Use high quality seed and feed
- Maintain a stage pond environment.
- Maintain dissolve oxygen (DO) level of atleast 4.0 ppm at 6 am
- Ideal water temperature is 28-32^0 C , if temperature exceeds 32^{0}C or is reduce below
- 28^{0}c, reduce feeding by 30%.
- Regular water exange depending on 'DO' and water quality.
- Reduce pond pollution.
- Improve water quality parameters for higher productivity.

2.4.11. DISEASES OF *MACROBRACHIUM ROSENBERGII*

It is generally claimed that *Macrobrachium* spp have an advantage in that these species are less susceptible to diseases than brackish water shrimp. But as the culture of *Macrobrachium* spp. especially that of *M. rosenbergii* is rapidly expanding and farmers are aiming at an increased production levels, in future diseases and water quality problems may play an important role in pond production. In general very few diseases in *M. rosenbergii* due to virus have been reported. At present 2 viral agents infecting and causing diseases in *M. rosenbergii* are of considerable importance.

A. IDIOPATHIC MUSCLE NECROSIS:

This disease is known by various names, such as, white muscle disease, muscle opacity or milky prawn disease. It causes massive larval mortalities in hatcheries and the mortalities can be sudden upto 60% of 28-day-old post- larvae in intensive rearing systems. The disease appears as multifocal diffuse opacity of striated muscle. IMN of *M. rosenbergii* is considered to be associated with environmental stresses including salinity and temperature fluctuation, hypoxia, hyperactivity and over crowding. Mortalities are associated with extensive necrosis of muscle fibers. It has been observed in various hatcheries. IMN may occur within one or two days following stocking in production ponds. Rearing post-larvae in nursery ponds before release into grow- out pond may reduce this problem.

Reversibility of the disease in early affected larvae has been observed in some hatcheries in Thailand. However, the disease progresses very rapidly from onset. Sarver et al, suggested that the prevalence of IMN in a population of post larvae serves as a useful indicator of their general health. In Thailand, the farmers always calculate the prevalence of IMN in the population and add this percentage of prevalence to the regular stocking density. They believe that IMN affected larvae will die within a few days of stocking. There is no affective treatment for this disease except minimizing environmental stressers.

B. MACROBRACHIUM MUSCLE VIRUS (MMV):

It affects PL with an epizootic disease similar to idiopathic muscle necrosis (IMN). Affected prawns exhibit white, opaque areas in abdominal segments accompanied by progressive weakening of feeding and swimming habit. Histopathology is similar to IMN syndrome, but unlike IMN a cytoplasmic inclusion body is found in the necrotic muscle. Electron microscopy shows icosahedral virus particles 22.9+3.6 nm size. Virus temporarily named MMV. MMV infects fresh water prawn in July and December within 10 days of moving PL to out door ponds. Abdominal segments 2-6 will become opaque. A mortality of 50-75% is seen within two weeks after transporting to grow out ponds.

IMN occurred in Malaysia, Thailand hatcheries. In spite of similar morphology of MMV with those of 5 penaeid and prawn parvo like virus, it differ primarily in target tissue (striated muscle). Other parvo like virus in fresh water prawn in hepatopancreas and nonpathogenic. MMV found only in *M.rosenbergii* in striated muscle and form basophilic inclusion within cytoplasm.

C. WHITE SPOT SYNDROME VIRUS (WSSN):

Infection of fresh water prawn with WSSN has been detected by using PCR. Clinical signs closely resemble white spot syndrome of shrimp. Larvae, PL, juveniles and adults are found to be PCR positive. Amplified PCR product has been found to be similar to that of natural infected penaeid WSSR. Fresh water prawn is susceptible to WSSR, hence great care should be taken to prevent epizootics of WSS in fresh water prawn.

Shell disease is attributed to water quality. Usually, a CaCo3, level of 50-100 mg/l is generally considered the optimum range for Macrobrachium. Juvenile *M.rosenbergii* accidentally exposed to total water hardness between 160 and 312 CaCo3 mg/l, in a heated recirculation system showed circular lesions on shell.

D. BLACK GILL DISEASE :

This disease is caused by precipitating chemical and nitrogenous waste products, which are implicated in melanization of the gills. Increasing levels of ammonia and nitrite in grow-out ponds results in growth suppression and mortality *Macrobrachium* is more susceptible to high nitrite and nitrate concentration than penaeid shrimps. Sub-lethal effects of nitrite could be fatal in chronic exposure, and may occur at less than 2 mg/l. Levels of nitrogenous compounds should be routinely monitored. When the level of nitrogenous compounds approaches the toxic level, the water must be changed. Histopathological studies of black gill disease of prawn collected from ponds in Thailand appeared to show that it was due to iron precipitation. This was probably the result of acid soil.

E. WHITE PRAWN DISEASE (WPD):

This is a disease of adult *Macrobrachium*, mainly females. Johnson has reported whitening in *M.ohioni* adults in Texas. The subcuticular tissues appeared milky but the muscles were normal. No microorganisms were demonstrated. Broughton and Poupard (1976) described a disease in *M.rosenbergii*, which they called white syndrome and was characterized by a dense opaque white colour with soft skeleton. Microscopically there was diffuse necrosis of striated body musculature with haemocyte in filtration. Role of poor nutrition is a likely cause of WPD.

F. YELLOW-ORANGE DISCOLORATION:

This kind of discoloration was recorded in both the species viz *M. rosenbergii* and *M. malcolmsonii*. In one harvest at fisheries Research Station Kovvali 18% of harvested population of *M. malcolmsonii* were found with this abnormal condition. The discoloration is probably due to leeching of pigment from hepatopancreas and flushing into the blood circulation. The factors that induced this condition are not clear. But the condition is generally noticed at the time of harvest when the bottom is distributed and there is a possibility of prawns being exposed to harmful gases.

G. PROTOZOAN DISEASES:

The most common conditions found are heavy accumulation of colonial Protozoan ectocommencel ciliates *Epistylis spp* and *Zoothanniun spp*. This condition is usually a sign of prolonged inter molt period due to old age, diseases and water quality problems. This condition is often found in terminal males the growth of which has almost ceased. The prawns move lethargically ad become sensitive to other stressor.

H. YEAST DISEASE:

The disease is caused by some species of yeast such as *Debaryomyces spp* and *Mitschinikowia spp*. This is a serious disease resulting in mass mortalities and responsible for the drastic decline *in M.rosenbergii* production in Taiwan since 1991. Yeast cells multiply in hemocytes and intracellularly in the gills, muscle and hepatopancreas. The infected prawns exhibit a whitish /green/yellowish muscle. They become sensitive and loose resistance to various stressing factors and this may results in mass mortalities. In Taiwan the susceptibility of prawns to yeast disease increased every year. It was noticed that the population explosion of yeast in culture ponds was due to accumulation organic matter at a high density. The disease was more virulent during October to March. It is believed that improve management of pond environment is essential.

I. PREVENTION OF DISEASES:

It is clear that many kinds of diseases and abnormal condition are due to deteriorated water quality and improper management practices. Hence, to prevent diseases implementation of certain sound management practices are necessary. They are proper pond preparation, selection of healthy seed, use of nutritionally balanced feed, efficient feeding management, prevention of organic matter accumulation at the bottom and frequent monitoring of health condition of prawns etc. These precautions are applicable to all types of diseases. There is no therapy for viral diseases.

J. THERAPY:

To treat bacterial diseases two lines of therapy is usually followed. To reduce pathogenic bacterial density in the pond sanitizers such as BKC, Idophores and Formalin etc may be applied as per the advise of Scientists. Approved Antibiotics may be added to the feed at 5 g/Kg feed consecutively for 5 to 7 days. Inducing prawn to molt may eliminate colonial protozoans growing on the body of prawn. Appropriate precautions are to be taken when therapeutic chemicals are applied in pond water or feed. Lastly, it must be emphasized that prevention is better than cure.

2.4.12. SUMMARY:

Freshwater prawn farming has very bright prospects, as scampi is an immediate alternative to tiger shrimp as a dollar earner. About a dozen species of fresh water prawns belonging to the genus *Macrobrachium* inhabit the Indian rivers and constitute a rich resource in terms of delicious protein food both for the rich and the poor. At least, three species, viz., *M. rosenbergii, M.malcolmsonii* and *M. birmanicum* choprai attain sufficiently large sizes and are economically very important. Of these, *M. rosenbergii*, which is the largest prawn in the world attaining over 300 mm in length and 400 g in weight, and popularly known as scampi or the giant long-legged prawn, is now cultivated on a large scale in Asia. The general biology and life history of *M.malcomsonii* indicates that the freshwater prawn is a very good candidate species for culture. The hatcheries for freshwater can be established easily because of the availability of the essentials. Techniques were developed for transportation of PL's to the culture ponds. Techniques involved in selection, transportation, breeding, hatching etc are discussed in detail. Rearing of PL's in nursery pond and its feeding techniques were discussed in depth. Preparation, stocking and optimum water quality parameters of grow-out ponds are given. Feed management strategies in culture system was described. Finally diseases of prawns and causes and prevention methods were described in detail.

2.4.13. MODEL QUESTIONS:

1. Write briefly about classification , biology and life history of freshwater prawn *Macrobrachium rosenbergii.*
2. Write about the essentials for the establishment of prawns hatchery.
3. Give an account of management techniques involved in nurseray pond.
4. Give an account of feed management techniques in freshwater prawn culture.
5. Describe the diseases of freshwater prawn and their control measures.

2.4.14. REFERENCES:

1. FAO, Freshwater Prawn Farming Manual.
2. Training Manual on Freshwater Giant Prawn Culture and Hatchery management .
3. Manuals of Training Programmes on Hatchery and Grow out technologies of Scampi.

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UNIT – III

LESSON - 3.1

CULTURE OF AIR - BREATHING FISHES

3.4.1. OBJECTIVES
3.4.2. INTRODUCTION
3.4.3. AIR-BREATHING FISHES
3.4.4. CULTURE SYSTEMS
3.4.5. COLLECTION AND REARING OF MURREL SEED
3.4.6. COLLECTION AND REARING OF CAT FISH SEED
3.4.7. STOCKING OF FINGERLINGS
3.4.8. FEEDING MANAGEMENT
3.4.9. GROWTH AND PRODUCTION
3.4.10. HARVESTING
3.4.11. SUMMARY
3.4.12. MODEL QUESTIONS
3.4.13. REFERENCE

3.1.1. OBJECTIVE:

To know the seed resources and culture techniques of air- breathing fishes.

3.1.2. INTRODUCTION:

The country has extensive weed-choked water areas with low dissolved oxygen suitable for the cultivation of air-breathing fishes like *Clarias batrachus (Fig. 1-6a), Heteropneustes fossils (Fig. 1-6b)*, *Anabas testudineus*, *Channa marulius (Fig. 1-11b)*, *Channa striatus (Fig. 1-11a)* and *Channa punctatus (Fig. 1-11c)*, which have many desirable traits.

The air – breathing fishes murrels and cat fishes are known for their esteem and good market demand owing to their low fat and few intramuscular spines. Further as they are hardy and are capable of breathing atmospheric air due to their accessory respiratory organs, they are suitable for culture in areas of low dissolved oxygen such as shallow foul waters and derelict ponds and swamps. Owing to their ability to live out of water for a fairly long time their culture involves low risk and simple management. Among the different species of murrels, the giant murrel, *Channa marulius,* Common or striped murrel, *Channa striatus* and spotted murrel, *Channa punctatus* and of cat fishes, the magur, *Clarias batrachus* and singhi, *Heteropneustes fossils* are suitable for profitable culture.

Cat fishes are the most commonly grown fish in the United states. In 1960 there were 400 areas devoted to their culture, but this has grown to tens of thousands of areas located primarily in the Southeastern states. When the water is cold there are only a limited number of catfishes farms in the Northern states.

The AICRP on air-breathing fish culture initiated in 1971, took up detailed investigation of on the development of cultural practices for optimum production of such fish under different management systems in the states of Karnataka, Andhra Pradesh, Assam, West Bengal and Bihar. A production of over one tonne/ha in 8 months was achieved in mixed culture of *Clarias, Heteropneustes* and *Anabas* without any supplementary feed or fertilizer. With supplementary feed of dried marine trash fish and rice bran, *Clarias* yielded over 5 tonnes/ha in 5 months while *Heteropneustes* yielded over 7 tonnes/ ha in 6 months. With feed made up of rice polish, trash fish and cow dung production rate as high as 50 tonnes/ha in 3 months for *Clarias* and 20 tonnes/ha in 3 months for *Heteropneustes* could be achieved with high density stocking, intensive feeding and water replenishment.

3.1.3. AIR – BREATHING FISHES:

3.1.3.1. *Clarias batrachus* (Magur):

Class – Teleostomi
Order – Siluriformes
Family- Clariidae
Genus – *Clarias*
Species –*batrachus*

This fish is found in fresh water of plains throughout India. This is usually found in the mud can survive independently on aquatic respiration. The body is elongated with laterally compressed head. The body colour is either uniformly reddish– brown or grayish black. It may attain a maximum length of 45cm. The chief food of this fish is prawn, aquatic insects, larvae, sand and algal filaments. Breeding season is from April to June. It is considered to be a delicious fish and is in great demand and fetches more price than carps. It is also found in Srilanka, Malaya, Burma and other countries. Now a days it is widely used as experimental fish for biological studies on pituitary hormones.

3.1.3.2. *Channa punctatus* (Gurrie):

Class – Teleostomi
Order – Perciformes
Family- Channidae
Genus – *Channa*
Species – *punctatus*

This fish is found throughout the plains of India and Pakistan. They prefer to live in stagnant waters. The colour of fish various according to surrounding water. It may attain a length of 31cm in plains but on hills it is only 11cm. The major food of this fish is aquatic insects, microorganisms, small fishes, mollusks and prawns. They are prolific breeders and the development is much rapid.

3.1.3.3. *Channa striatus*(Sowra):

Class – Teleostomi
Order – Perciformes

Family- Channidae
Genus – Channa
Species – striatus.

This is found in the fresh waters of Uttar Pradesh, Punjab and South India. The body of this fish is dark – brown or black dorsally and yellowish from the ventral side. They are main bulk of pond fishes. They always prefer stagnant, muddy waters and feed on worms, tadpoles, other fishes, insects, frogs and even on small snakes. After two years of age females get matured and start breeding throughout the year in ponds but peak breeding is noticed in monsoon period. The fully developed fish may attain a length of about 90cm. This fish is very economical and is more palatable even than Rohu and Catla both. Due to these reasons they are costly and in greater demand in markets.

3.1.3.4. *Channa marulius* (Ham.) Saul

Class - Telestomi
Order - Perciiformes
Family- Channidae
Genus- Channa
Species- marulius

This fish is distributed in fresh waters of India, Pakistan, Sri Lanka and China. This fish prefers deep clean water with sandy or rocky bottom specially at the junctions of streams. This may be cultured in irrigation wells also in South India. They may attain a length up to 122 cm but are usually of 46 centimeters . They prefer to feed on carps, kitchen refuse, frogs and dead animals. The fry can be safely transported by road with only a few changes of water. The breeding season is from April to June.

3.1.3.5. *Anabas testudineus* (Anabas):

Class – Teleostomi
Order – Perciformes
Family- Anabantidae
Genus – Anabas
Species – testudineus

This fish is found in estuaries and fresh waters of India and are costly and highly nutritive. The body of this fish is stout, almost cigar shaped, slightly compressed, with a wide head and green or greenish brown in colour. They may attain a length of 26cm. This fish is carnivours in nature and has been reported to leave the water in search of earth worms etc. for food. This fish can survive out of water in moist air for six days. The young ones are voracious feeders. It has a pleasing flavour and is very popular as food.

3.1.4. CULTURE SYSTEMS:

A water area of 0.1 ha with a depth of 50-75cm is ideal for air-breathing fish culture. Unlike carp ponds, ponds for air-breathing fish culture need not be fertilized by chemical and organic fertilizers. However, if the ponds are found infested with predators, they should be treated with mahua oilcake at the rate of 2,000 kg/ha and after 15 days, the pond bottom is raked for the liberation of toxic gases. In the case of silt-loaded bottom, it is advisable to add lime at the rate of 250 kg/ha, which may not only reduce the toxicity of gases but may also enhance the fertility of the pond.

Cage culture of the air-breathing fish may also be undertaken in running water systems like streams and channels and unmanageable water bodies like reservoirs. Floating nylon cages (1x1x1 m) supported with wooden reapers or bamboo cages of 2 x 1 x 0.8 m with interspaces may be used for this purpose. Constant flow of water in these cages facilitates regular supply of Oxygen. It is also necessary to provide hide-outs, such as tiles and hollow bamboo sticks, especially for the murrel rearing cages, as murrels are known for their cannibalistic habit.

3.1.5. COLLECTION AND REARING OF MURREL SEED:

Murrel attain maturity in two years and are known to breed throughout the year. The fry of 2-4cm size can be collected all round the year from rain-fed ditches and shallow water bodies with abundant weeds. However, peak spawning is known to occur just before the rains (May-June; December-February). As the young move in schools, their collection in large numbers is always easy. Further, it is worth mentioning that when the young reach the fingerling stage, they may not tend to move in schools. The fry of murrel can be identified by their dark and grey body with a lateral orange-yellow band from eye to the caudal fin. The fry of striped murrel on the other hand, have a bright-red with a reddish-golden band and a dark-black band from eye to the caudal fin. The spotted murrel fry possess dark-brown body with a golden-yellow lateral band and a mid-dorsal yellow line on the back.

For ponds where murrel culture is to be undertaken, it is necessary to stock the fingerlings rather than the fry. Though the murrel seed can also be produced by induced breeding technique, it is difficult to maintain the spawn and grow them to fry stage, as the spawn do not eat on anything for about two days after their emergence from eggs. Owing to this, survival rate of fry produced through induced breeding will ordinarily be poor. Considering this, the fry are to be reared in suitable cement ponds or plastic pools and trained to accept supplementary feed. The supplementary feed for the growing fry consists of boiled eggs, silkworm pupae, minced trash fish and worms and is given for about 15 days at the rate of 20 per cent of their total body weight. If suitable feeds and water quality are maintained, the fry may reach the fingerling stage (4-6 cm) within a month, for stocking in culture ponds.

3.1.6. COLLECTION AND REARING OF CAT FISH SEED:

In *C. batrachus*, the sex is distinguished when it is one year old or attains a length of about 20 cm. The matured male possesses pointed anal papillae, which is oval in shape in female. Though magur breeds throughout the year, peak breeding is encountered during rainy seasons. During spawning, which takes place in fairly deep waters, the female makes a hole of 20 cm diameter and 25 cm depth in the bund below the water surface. The fertilized eggs (1-1.5 mm) are yellowish – brown in colour and adhere to grass. The eggs are guarded by the male, hatch within 20 hours at a temperature range 25-30 °C. Fry numbering 2,000 – 15,000/hole may be collected from natural areas with the aid of small fine-meshed hand net and reared in nurseries until they reach fingerling stage (5 cm).

Pond breeding of magur can also be done for the production of fry. Here, compartment or enclosures (1 x 1 m) of wire screen are made on the margin of the bund having a water depth of about 25 cm. At the center of the compartment, a hole of 30 cm diameter is dug and is provided with some aquatic plants. The male and female fish suitable for breeding are then introduced. The fish spawn within a period of 10 days and a maximum of 5,000 fry could be expected from each compartment. Alternately, the male and female fish may be induced by hypophysation technique. The dosage of pituitary extract effective for cat fish is 10 mg for fish weighing 100 g, 25 mg for 100-150 g, 35 mg for 150-200g. The spawning takes place within 15 hours. The eggs produced by induced breeding may be placed in shallow troughs or hatching jars. The water must be changed twice a day, preferably during morning and afternoon. The eggs hatches out in about 20 hours and the yolk sac is absorbed after five days.

Unlike murrels, catfish produced through induced breeding or collected from natural sources, could be reared either in small earthen ponds of 1.5 x 3.0 x 0.5 m size or in floating baskets of 1.0 x 1.5 x x1.0 m, maintaining a stocking density of about 20,000 per pond or basket. These fry may be fed either with filtered zooplankton or chopped fish flesh and groundnut oil cake. The fry are reared fo two weeks and are then used for stocking.

3.1.7. STOCKING OF FINGERLINGS OF MURREL AND CAT FISH:

The transportation of air-breathing fish seeds is not at all a problem. If the period of journey is less than five hours, the fingerlings may be transported in open and watering tin carriers or in mud pots with a small amount of aquatic weeds such *as Hydrilla, Vallisneria, Ceratophyllum* and *Myriophyllum*. The weeds may help avoid jumping of the fish during transportation. However, if the fish are to be transported for distant places, which may take longer time, they should be transported in oxygen-packed polythene containers as described elsewhere. For stocking, uniform sized fingerlings are to be chosen. The selected once before stocking are to be treated with 2 per cent potassium permanganate solution for about five minutes or dipped in 200 ppm formalin solution for 50 seconds. Wounded fish, if any, may be treated with 0.3 per cent acriflavine for five minutes.

Unlike the carp ponds, the inner sides of bunds of ponds suitable for air-breathing fish culture, should be either firm with heavy log of wood, or fenced with bamboo, cane or wire screens to a height of about 50 cm. Such provisions may help to avoid the air-breathers from escaping through climbing or burrowing.

The stocking rate can be considerably enhanced owing to their air-breathing habit. Generally, for the monoculture of air-breathing fish species, a stocking density of 50,000/ha with an individual size of 10 cm may be maintained.

Mixed culture either of murrels and carps or of catfish and carps can also be attempted with proper care and management. However, in these culture systems, the seeds of air-breathing fish should be stocked only when the carps had grown to a minimum of 300 g each, so that the former may not prey on the latter. By this practice, not only on additional income can be obtained through the yield of air-breathing fish, but also the growth of carps can be enhanced. The latter is possible, as the trash fish which may compete with culturable carps for food and space, in the event of their entry in the culture ponds are eradicated by the growing air-breathers.

3.1.8. FEEDING MANAGEMENT:

In order to maintain an abundant food supply for the growing air-breathers, the stocking ponds must be rich in animal food sources like frog tadpoles and trash fish. If these food sources are found inadequate, tilapia may also be grown in murrel and catfish ponds, so that, the young of tilapia may serve as a regular and staple food source to the growing murrels and catfish. In order to enhance the growth of the air-breather, supplementary feeds made of soaked trash fish and slaughter house waste in the ratio of 1:1, rice-bran, mustered oil cake and trash fish meal in 2:1:1, rice-bran and poultry feed in 3:1, bio gas slurry and rice-bran in 1:2 or poultry dropping and rice-bran in 1:2 may be given daily at the rate of 5-8 per cent of body weight of the fish fingerlings stocked or as per the following schedule.

Period of culture	Weight of feed, kg/day (Stocking density, 50,000/ha)
1st-2nd month	10
3rd-4th month	20
5th-6th month	30
7th-8th month	40

The feed may either be broadcast in the pond from the bund or may be served in feed baskets. It is very interesting to note that the murrels and catfish come in shoals when the feed baskets are lowered in water near the bunds. It is reported that better feed utilization can be expected in the case of catfish, if they are fed during dark hours. Further, if the ponds of air-breathers are nearer to rice and other agricultural fields, light traps can be installed in murrel ponds. By doing so, the insects which may do harm to crops may be attracted by light and brought to the growing air-breathers as a protein-rich food source.

3.1.9. GROWTH AND PRODUCTION:

The marketable size of murrels and catfish could be obtained in a period of eight months and six month respectively. If proper management particles are adopted, giant murrel and striped murrel can attain a growth of 1-2 kg/yr and 0.5-0.75 kg/yr respectively. However, compared to murrels, catfish are known to grow slowly and the growth rates reported for a period of four months for magur and singhi have been 0.2 kg and 0.1 kg respectively.

An average air-breathing fish yield of 4-6 t/ha/yr can normally be obtained from culture ponds. However, through intensive fish culture practices which involve heavy stocking and feeding, a production of 107 t/ha/4-5 months has been reported in the culture of magur *C. batrachus* with an average growth rate of 40 g/month. Since the culture period for catfish is only 4-5 months, two to three crops may be obtained in a year from a fishpond.

3.1.10. HARVESTING:

Summer season is ideal for harvesting air-breathers from production ponds. Invariably, the pond is drained and the fish are harvested with the help of hand nets or scoop nets. Owing to the heavy demand, simple management and high cost of air-breathers, an income RS.20,000/ha/yr is possible through their culture.

3.1.11. SUMMARY:

1. Air-breathing fishes like cat fishes (Clarias batrachus, Heteropneustes fossilis), climbing perch (Anabas testudineus) and murrels (Channa marulius, C.striatus, C.punctatus) have been cultivated extensively in weed-choked water areas with low dissolved oxygen as they are capable of breathing atmosheric air due to their accessory respiratory organs.

2. In traditional polyculture of Clarias, Heteropneustes and Anabas with no supplementary feed production levels are low whereas in improved cultures with high density stocking, intensi feeding and water replenishment, the yields are much higher.

3. The culture systems for air-breathing fishes are ponds and cages. Small ponds of 0.1 ha with a depth of 50-75 cm are ideal for culture. Floating nylon cages or bamboo cages of 2 x 1x 0.8m are generally used for culture. Constant flow of water and hideouts are provided in cages.

4. Murrel attain maturity in two years and are known to breed throughout the year. However, peak spawning occur just before rains (May- June; December-February). The fry of 2 – 4 cm can be collected throughout the year from shalow water bodies with abundant weeds. The survival rate of fry produced through induced breeding is poor. Hence, fry are to be reared in suitable cement ponds or plastic pools and trained to accept supplementary feed. If suitable feeds and water quality are maintained, the fry may reach the fingerling stage (4-6cm) within a month. The murrel culture ponds are stocked with figerlings rather than the fry.

3. The magur, Clarias batrachus also breeds throughout the year with peak breeding during rainy season. Spawning takes place in a hole in deep waters made by the female. Eggs are gaurded by the male. Fry numbering 2000 –15,000/hole can be collected and reared in nurseries till they reach fingerling stage (5 cm)

4. Pond breeding of magur can also be done artificially by making a hole provided with aquatic plants in a compartment made on the margin of the bund. Then male and female fish are introduced.Spawning takes place within 10 days and fry are produced. Alternatively, the male and female fish ma y be induced by hypophysation technique using pituitary extract. The fry can be reared either in small earthen ponds or in floating baskets for two weeks and are then used for stocking.

5. The air-breathing fish seed are transported in open water tin carriers with aquatic weeds. For long distance transportation, oxygen-filled polythene containers are used. For stocking , uniform sized fingerlings are chosen. Before stocking prophylactic treatments are given. Then the pond margins are fenced to a height of 50 cm to avoid escaping of fish from the pond.

6. Owing to their air-breathing habit, they can be stocked at higher densities. For monoculture, a stocking density of 50,000/ha with 10 cm sized fish may be maintained. Mixed culture of murrels and carps or of cat fish and carps can also be done.

7. For growing the air-breathers the stocking ponds are maintained with rich animal food sources like frog tadpoles and trash fish. Tilapia can also be grown in murrel and cat fish ponds as their young ones serve as a regular and staple food source. To enhance the further growth of air-breathers, supplementary feeds containing trash fish, slaughter house wastes, rice bran, etc. daily at the rate of 5 to 8 % of the body weight of fish stocked are fed.

8. Murrels and cat fishes reach the marketable size in eight and six months respectively. Giant murrel and striped murrel can attain a growth of 1-2 kg/ha and 0.5 - 0.75 kg / yr respectively. Cat fishes grow slowly and attain a size of 0.1 to 0.2 kg in a period of four months.

9. An yield of 4-6 t/ha/yr can normally be obtained from air-breathing fish culture ponds. However, under intensive culture practices, a production of 107 t / ha / 4-5 months has been reported in the culture of magur. Since the culture period is only 4-5 months, two or three crops may be obtained in a year.

3.1.12. MODEL QUESTIONS :

1. Write briefly about morphological features of Air breathing fishes.
2. Write a detailed account on the collection and rearing of different air breathing fish seeds.

3.1.13. REFERENCES

1. A manual of Fresh water Aquaculture. R.Santhana eta al. Oxford & IBH Pub. Co. New Delhi.
2. Economic Zoology. G.S.Shukla & V.B.Upadhyay. Rastogi Publications., Meerut.

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UNIT – III

LESSON - 3.2

CULTURE OF SEA-BASS, *LATES CALCARIFER*

3.2.1. Objectives
3.2.2. Introduction
3.2.3. Fry collection
3.2.4. Induced spawning
3.2.5. Larval rearing
3.2.6. Grow-out
3.2.7. Summary
3.2.8. Model Questions
3.2.9. Reference Books

3.2.1. OBJECTIVES:

The purpose of this lesson is to

* learn the occurrence and fry collection in natural habitats and
* describe the methods of induced spawning, larval rearing and grow-out of Asian Sea-bass, *Lates calcarifer*.

3.2.2. INTRODUCTION:

Lates calcarifer, the Asian sea-bass, also known as kakap (Cockup) and giant perch (Fig. 1-10), belongs to the family Centropomidae. It is one of the important food fishes cultivated in brackishwaters. It is distributed in the littoral waters from Iran to Australia. It is a euryhaline fish and carnivorous. They fetch high prices in the markets. Landings from capture fisheries are reported to be declining and there is an increasing and unsatisfied market in major consuming areas. Consequently, aquaculture-produced sea-basses have the potential for enhancing both domestic and export trade. Though it is a predatory fish, its market and culinary values made it acceptable in culture systems.

Historically, the sea-bass has been the constituent of stocks in Indian bheris, Mediterranean vallis and coastal fish farms in Southeast Asian countries. The stocks in these impoundments are derived from eggs, larvae or fry brought in by the incoming tides. In recent years the rearing of wild and hatchery produced fry and fingerlings in cages and ponds have shown potential for intensive culture of this species. Methods of artificial propagation have been developed and commercial scale production is established in a number of areas.

The main handicap for intensive culture of *L. calcarifer* has been the lack of dependable source of fry and fingerlings. Though wild fry can be collected from natural habitats, the supply is highly inconsistent and inadequate. Because of this, many recent scientific studies on this species have been focused on developing methods of induced spawning and larval rearing.

The *Lates calcarifer* occurs in the tropical and sub-tropical areas of Asia. It is a highly euryhaline species that lives in brackishwater estuaries and in freshwaters. For spawning they require saline water, but larvae occur in freshwaters including rice fields. The adult sea bass is a voracious carnivore, but juveniles are omnivorous. One of the major problems in culturing them in ponds is their cannibalistic habits.

3.2.3. FRY COLLECTION:

The fry of the cock-up are available during May-October season in the Matlah and other lower stretches of Hooghly estuary in West Bengal and during July–August in Chilka lake. They are also collected from the intertidal pools in the Sunderbans bheries in West Bengal, Muthupet saline swamp in Tamilnadu and the northern sector of Pulicat lake. Fine meshed hapa nets are used for fry collection.

3.2.4. INDUCED SPAWNING:

In nature, *L. calcarifer* spawns throughout the year with the peak season from April to August. Though it does not spawn normally in confined areas, methods of induced spawning have been developed. Induced spawning can be done either by hypophysation or by environmental manipulation of salinity and temperature in the ponds.

Brood fish can be obtained from culture ponds or from open waters and reared in special earthen brood ponds, cement tanks or floating cages. It is reported that males predominate among smaller size groups (1.5-2.5 kg body weight), but 3 to 4 year old fish from culture ponds show a normal distribution of sexes. Three-year-old females, weighing 3.5–5 kg and two-year-old males weighing about 2.5–5 kg are preferred for artificial spawning. Spawning can be carried out in concrete tanks of about 150 ton capacity with a suitable supply of saline water (28–32 ppt), with periodic water exchange and aeration.

The brood fish are introduced into the spawning tanks at the rate of about 10-20 pairs/tank, atleast one month before the spawning. The *mature female* is recognized by the red-pink papilla extending out at the urinoginetal aperture and the soft belly. The *male* is usually more slender, with slightly curved snout and, when mature, milt oozes out on slight pressure on the abdomen. Females with oocytes of about 0.5 mm diameter are suitable for induced spawning.

The hormones usually used to induce spawning are HCG (Human Chorionic Gonadotropin) with pituitary gland of carp and puberogen. Puberogen contains 63% follicle stimulating hormone (FSH) and 34% leutinizing hormone (LH). The spawners are usually given two intra-muscular injections at the base of the pectoral fin. The first dose is of 50 IU HCG and 0.5–1 pituitary gland, and the second dose after 12 hrs, of 100–200 IU HCG and 1.5–2 pituitary glands. Within about 10-12 hrs after the second injection, spawning occurs. Repeated spawnings occur in batches over a period of 3-5 days. The fecundity ranges from 2-17 million eggs, depending on the size of the spawner. Fertilized eggs float on the surface of the tanks and can be siphoned out for hatching. If the brood fish do not spawn in the tank after the second injection, they are stripped and the eggs fertilized artificially.

When puberogen is used to induce spawning the dosage is usually 50-200 IU/kg body weight for the female and 20-25 IU/kg body weight for the male. If spawning dose not occur within 36 hrs, a second injection is given and the dosage doubled. This leads to spawning within 12-15 hrs.

Induced spawning by environmental manipulation involves changing the salinity and temperature, simulating conditions in the natural spawning areas during the lunar phases. The salinity in the brood fish tank is gradually increased from 20-25 ppt to 30-32 ppt after the spawners are stocked, simulating the increased salinity to which the fish are exposed during migration from coastal areas to the sea. The pre-spawning behaviour of the spawners is carefully monitored. Segregation of the sexes may be done about a week before spawning. Spawning normally takes place during the full moon and new moon periods. At this time, the temp of the water in the spawning tank containing the females and males is raised to 31-32^{0}C by lowering the water level to about 30 cm and exposing the water to the sun for 2-3 hrs. Then the water temperature is suddenly lowered to 27-28^{0}C by the addition of filtered sea water. This induces the fish to spawn during the succeeding night. In case of failure the procedure is repeated. The fish usually spawn intermittently for about 3-7 days.

The fertilized eggs are incubated in 50 l capacity hatching jars or fiberglass tanks. Such containers can hold 50,000 – 100,000 eggs. A one-minute bath in 5 ppm acriflavine followed by repeated rinsing in salt water is recommended before the eggs are introduced into hatching jars for hatching. The best hatching rates have been observed in salinities between 20 and 30 ppt. With proper aeration and salinity, the eggs hatch out in about 17-18 hours at temperatures of 26-28^{0}C. The hatchlings are about 1.5 mm in length.

3.2.5. LARVAL REARING:

The hatchlings can be reared to fry stage in large nursery tanks, supplied with water of about 20 ppt salinity. The stocking density varies with the age and size of the larvae. Initially they are stocked at the rate of 40,000 – 50,000/m^3. By the fourth week they are gradually thinned out to 2000 – 5000/m^3.

Sea bass larvae require live food in their early stages. In hatcheries, the first food given to 3-day-old larvae consists mainly of rotifers (*Brachionus plicatilis*), with a small percentage of *Chlorella* sp. and *Tetraselmis* sp., at the rate of 5-10 per ml. This may continue until the fourteenth day, with the addition of *Artemia* nauplii from 8th day to the 20th day. The suggested density of *Artemia* is 1 or 2/ml. Usually the larval density in the tanks is reduced to about 20–40 larvae/l, about a week after feeding starts. From the 16th day, *Daphnia* or *Moina* can be added, at a density of 1 or 2/ml, several times a day. After about 3 weeks, the fry are fed on minced fish. Generally the fry are graded during rearing, to separate out the fast growing ones from the others. Sorting and separation of fry according to size and thinning of stock help in reducing cannibalism among the fry. After about a month, the fry attain a size of about 12 mm and are then used for grow-out in production ponds or cages.

3.2.6. GROW-OUT:

This includes growing fish from fry to market size. *L. calcarifer* has been cultivated for many years in brackishwater ponds, and in recent years in floating cages, but there is a lack of documented information on grow-out practice.

The main problems of grow-out are feeding and prevention of cannibalism among young fish. In order to reduce losses due to cannibalism, grow-out is performed in two phases. In the first phase, the fry are grown to a weight of about 20g in special nursery ponds of upto 2000m^2. The ponds are initially fertilized to enhance the natural food. Fry are stocked at the rate of 20-30/m^2. Besides the natural food produced by fertilization, the fry are fed with supplementary feed consisting of adult *Artemia* and ground trash fish twice a day. Exchange of water at the rate of 30% daily is maintained. The rearing period is about 30-45 days. By frequent sorting, fish of similar size are separated and stocked in separate grow-out facilities for growing to market size.

Grow-out to market size lasts for 3-4 months in countries like the Philippines, where 300-400g fish are acceptable, and 8-12 months in other countries where 700-1200g fish are preferred. Floating and stationary cages of different sizes (usually 50m^3) are used. The stocking density in the cages is about 40-50 fish/m^3, but after a growth of about 3 months the stock is thinned out to 10-20 fish/m^3. The usual feed is chopped trash fish, fed twice daily at the rate of 10% of body weight initially. After about two months, they are fed only once a day at 50% of the body weight. When insufficient trash fish is available, rice bran or broken rice is added as a partial substitute.

Both monoculture and polyculture of sea-bass are practised. In intensive polycultue with the sea-bass as the main species, the subsidiary species are forage fish like tilapia. In such polyculture, the ponds are first stocked with the forage fish, which reproduces rapidly. When a sufficient stock of fry and juveniles of the forage has developed in the pond, sea-bass juveniles are stocked at the rate of 3000–5000/ha. In monoculture systems the stocking rate is usually 10,000–20,000/ha of uniform size juveniles which are fed daily with trash fish.

In traditional ponds, the sea-bass attains sizes around 500g in about 12 months. A gross production of about 2.76 tons/ha in 8 months has been reported. It has been estimated that in monoculture, in ponds with multiple stocking and harvesting, a production of about 3.3 tons/ha can be obtained.

3.2.7. SUMMARY

1. *Lates calcarifer* is commonly called the Asian sea-bass, cockup and giant perch. It is one of the important food fishes cultivated in brackish water bodies. It is a euryhaline fish and distributed in the littoral waters from Iran to Australia.

2. It is a predatory fish. Inspite of their predation on other finfish and crustaceans, their market and culinary values made them acceptable species in culture systems.

3. The sea-bass has been the constituent of stocks in Mediterranean vallis, Indian bheris and coastal fish farms in Southeast Asian countries. The stocks in these impoundments are brought in by the incoming tides.

4. The major problem for intensive culture of sea-bass is the lack of dependable source of fry and fingerlings from natural habitats. Cannibalism is the another problem for culturing them in ponds.

5. The fry of *L. calcarifer* are available during May–October from Hooghly estuary and sunderban bheries in West Bengal, Chilka lake, Pulicat lake and Muthupet saline swamps in Tamilnadu. Fry are collected by using fine meshed hapa nets.

6. *L. calcarifer* spawns throughout the year with the peak season from April to August in natural habitats. It does not spawn in confined water. For controlled spawning in ponds induced spawning methods are followed.

7. Brood fish are collected from open waters or from culture ponds. Three-year-old females (3.5–5 kg) and two-year-old males (2.5–5 kg) are preferred for artificial spawning. They are stocked in spawning tanks (150 ton capacity) at the rate of 10-12 pairs/tank a month prior to spawning.

8. The hormones used for induced spawning are HCG with pituitary gland of carp and puberogen. The spawners are given two intra-muscular injections of pituitary glands and HCG. After second injection, spawning occurs in 10-12 hrs. The fecundity ranges from 2-17 million eggs. Fertilized eggs floating on the surface of the tanks are transferred to hatching jars or tanks.

9. Induced spawnign can also be done by environmental manipulation. It involves changing the salinity and temperature so as to simulate the conditions in the natural spawning areas during lunar phases.

10. The fertilized eggs are incubated in 50 l hatching jars or fiberglass tanks containing saline water of 20 to 30 ppt. The eggs hatch out in 17-18 hrs at 26-28°C. The hatchlings are about 1.5 mm in length.

11. The hatchlings are reared to fry stage in nursery tanks for about one month. The larvae are fed with live food like rotifers, algae, cladocerans and artemia nauplii upto 3 weeks. Afterwards they are fed with minced fish. In one month, the fry attain a size of about 12 mm and are then stocked in grow-out ponds or cages.

12. To overcome the problem of cannibalism among young fish, grow-out is performed in two phases. In the first phase, they fry are grown to 20g size in special nursery ponds for about 30-45 days. The second phase includes grow-out to market size in cages or ponds.

13. Both monoculture and polyculture of sea-bass are practised. In polyculture, sea-bass as the main species and the forage fish like tilapia as subsidiary species are used. The sea-bass juveniles are stocked at the rate of 3000–5000/ha in polyculture and 10,000–20,000/ha of uniform size in monoculture. A gross production of about 2.76 t/ha/8 months has been reported.

3.2.8. MODEL QUESTIONS:

1. Give an account of the culture of asian sea-bass, *Lates calcarifer*.
2. Write notes on
   a. Methods of induced spawning in cockup
   b. Grow-out practices of *Lates calcarifer* culture.

3.2.9. REFERENCE BOOKS:

Jhingran, V.G. 1985. *Fish and Fisheries of India.* Hindustan Publishing Corporation (India) Delhi.

Pillay, T.V.R. 1990. *Aquaculture Principles and Practices,* Fishing News Books, Ltd., Oxford.

Dr. P. PADMAVATHI

LESSON - 3.3
CULTURE OF MILK FISH, *CHANOS CHANOS*

3.3.1. Objectives
3.3.2. Introduction
3.3.3. Culture systems
3.3.4. Fry collection
Fry collection methods
3.3.5. Induced spawning
3.3.6. Rearing of fry
A. Pond preparation
B. Lablab maintenance
C. Plankton maintenance
D. Fry stocking and Acclimatization
E. Nursery pond management
F. Transition pond management
G. Wintering pond management
3.3.7. Grow-out
A. Pond preparation
B. Fish stocking
C. Feeding and pond management
D. Diseases
3.3.8. Pen culture
3.3.9. Harvesting and Marketing
3.3.10. Summary
3.3.11. Model Questions
3.3.12. Reference Books

3.3.1. OBJECTIVES

The purpose of this lesson is to

* know the culture importance, culture systems and fry collection of milk fish, and
* learn the methods of induced spawning, fry rearing, grow-out and harvesting of milk fish, *Chanos chanos*.

3.3.2. INTRODUCTION

Chanos chanos, popularly known as milkfish or the white mullet (Fig. 1-9b), is the only species of the family Chanidae and order Gonorhynchiformes. It is a well-known marine fish throughout the Indo-pacific region. The milkfish is a fast growing euryhaline food fish suitable for culture in brackishwater ponds. Milkfish is an important food fish in Indonesia, the Phillippines and Taiwan.

Infact, these countries are the major milkfish producing countries followed by a few other Asian countries including India. However, much of the brackishwater aquaculture experience in Asia has originated from milkfish farming. The culture of milkfish in India was introduced by the Hyder Ali from the sea to the tanks of South Kanara district. The attempts made for culture of milkfish at Narakkal and Kurusadai Island in 1940s and 1950s thrown considerable light on brackishwater farming.

Milkfish are herbivorous and detritus feeders. Inspite of some advances made in induced breeding, culture of this species is still based on wild fry and fingerlings. Though essentially a marine fish of the Indian and Pacific oceans, the young ones spend their life in inshore estuarine areas and ascend rivers to the freshwater zones. They are known to be highly euryhaline and can live in fresh to hypersaline waters and can tolerate low oxygen levels. Temperature tolerance limits are said to range from 15-40°C, but the optimum is between 20-33°C. They become sluggish below 20°C and mortality occurs at 12°C.

It does not form a capture fishery of any significance and its importance is based on the large-scale farming in over 4,00,000 ha of coastal impoundments in Southeast Asia. Its culture is believed to have originated in Indonesia during the 15th century and then spread to the Philippines and Taiwan. The average production in Taiwan is reported to be about 2 tons/ha, in the Philippines 600 kg/ha and in Indonesia about 300 kg. Many individual farms obtain much higher production in all three countries. Some small scale culture is attempted in peninsular India and Sri Lanka, but the total production is very small. In India, milkfish culture is taken mostly in the states of Bengal, Kerala, Tamilnadu and Andhra Pradesh by trapping fry during high tides from the smooth and shallow waters of the Bay of Bengal. The traditional culture practices yield production less than 500 kg/ha/year. In semi-intensive farming, the production ranges between 2000 and 4000 kg/ha/year.

3.3.3. CULTRUE SYSTEMS

The most common system used for the culture of milkfish is the brackishwater coastal pond. The ponds may include nurseries and rearing ponds, with wintering ponds where the fingerlings have to be over wintered, as in Taiwan. Some farms may have only nurseries and some have only rearing ponds.

In traditional ponds, though intended for monoculture, brackishwater milkfish ponds become polyculture systems as the tidal water brings in early stages of a number of other species, the most important of which are the grey mullets, shrimps and sea bass.

Milkfish are sometimes grown in freshwater ponds or stocked in lakes and reservoirs. But the more important milkfish farming in freshwaters is the pen farming that has been developed in lakes in the Philippines (Laguna de Bay and Lake Sampaloc).

3.3.4. FRY COLLECTION

Milkfish do not mature and spawn naturally in confined waters. They spawn in the sea near the coast and the small larvae (12-15 mm in length) occur periodically along the sandy coasts and in the estuaries. The collection and rearing of fry from these areas for sale to farmers has become an industry of importance, employing a large number of people in Indonesia, the Philippines, Taiwan and even in some places of India.

In the Philippines and Taiwan, the season for collection extends from March to August, but the peak season in the Philippines is May/June and in Taiwan it is April/May. In Indonesia there are two seasons, one from March-May and the other from September – December. The peak period of collection is October/November.

In India, fry are available in abundance from March-June and in small quantities from September – November. Almost all the tidal creeks, estuaries and backwaters along Tamilnadu, Andhra, Orissa, Kerala and Karnataka coasts provide collection grounds for *Chanos* fry. In Tamilnadu the most important collection centres are Pamban, Pulicat, Kovalam, Cuddalore, Parangipettai, Muthupet and Tuticorin. In Andhra Pradesh, *Chanos* fry are obtained in large numbers from the estuaries and backwaters of Godavari and Krishna river systems. In Pulicat lake *Chanos* fry occur from February to October. In West Bengal the fry are found in the Bokkhali region in lower Sunderbans.

Fry Collection Methods

The most common fry collecting devices are dip nets, scoop nets, seines, drag nets and traps. Special fry-congregating devices used are rock walls or lure lines made of fibre ropes strung with plaited strips of coconut and banana leaves. When the fry congregate under the lure, they are collected with dip nets or scoop nets. The best collections are made at creek mouths, at high tides during full and new moon periods.

The fry collected fry (10 – 30 mm) are transferred to earthen-ware jars and transported to ponds in the Philippines. In Taiwan, they are temporarily stored in wooden buckets or cement troughs in sea water. Then they are packed in plastic bags containing low saline water (10 – 15 ppt) and filled with oxygen for transport. Recently, in the Philippines also transportation is carried out by plastic bags. In Indonesia, flat bamboo baskets coated with cement or tar are used for fry transport. During long-distance transport or storage, the fry are fed on slightly roasted rice flour or wheat flour twice a day, and occasionally on mashed hard-boiled eggs.

3.3.5. INDUCED SPAWNING

Attempts have been made to develop a hatchery technology for the production of milkfish fry inorder to meet the increasing demand of intensified farming. The sexes can be distinguished by external characteristics. Females are distinguishable by the presence of three visible pores in the urinogenital region, whereas the males show only two pores externally. Mature females collected from the sea (with ova of about 0.7 – 0.8 mm diameter) can be induced to spawn by the administration of carp pituitary homogenate, semi-purified Salmon Gonadotropin (SG-G 100) in combination with HCG. The average number of eggs spawned annually is estimated to be 2 million/kg body weight. The eggs can be fertilized with milt from untreated males. When necessary, the free flow of milt is induced by the injection of androgen or salmon pituitary preparations.

The fertilized eggs can be hatched in salt water (30 – 34 ppt) containers in 25 – 28.5 hours at 26 – 30°C. However, it is difficult to rear the post-larvae to the fry stage in significant numbers. Survival rates under experimental conditions have been reported to be 9–47% during a 21-day rearing period. Fed initially on fertilized oyster eggs for 14 days and thereafter on a combination of copepods, Artemia nauplii, flour and prepared feed, the fry could be grown to a mean size of 15 mm in 20 days.

Spawning in open waters showed good results. It has been shown that milkfish can attain sexual maturity and spawn in cages installed in protected bays. Floating cages fitted with fine-meshed hapa nets to retain milkfish eggs have been successfully used by research institutions for large-scale spawning. The eggs are collected from the cages with a specially designed conical egg-sweeping net, with a rigid frame. This device is reported to have been very successful in the recovery of fertilized eggs and thereby in the production of hatchery produced fry.

3.3.6. REARING OF FRY

For fry rearing, separate nursery and transition ponds are being maintained in some farms. They normally represent about 3-5% of the farm area. The nursery ponds are shallow and ranging in size from 1000 to 4000 m². They are located close to transition ponds which are meant for stunting the fry for later (off-season) stocking. They usually average about 1 ha in area. The nursery ponds are provided with catching ponds, sluice gates and a canal system for easy water distribution and transfer of stock. When the nurseries form a unit of the production farm, their preferred location is in the center of the farm to facilitate transfer of fingerlings. Milkfish fry are usually grown to fingerling size in ponds with rich growths of benthic biological complex predominated by blue-green algae, generally referred to as lablab.

Lablab includes large populations of bacteria, diatoms, blue-green algae, green algae and animal components like protozoans, flatworms, polychaete worms, copepods, decapod larvae, insects and larvae and adults of mollusks. In recent years, many farmers have adopted the practice of raising mainly planktonic organisms as food for milkfish fry. In shallow ponds, the distinction between benthic growths and plankton is seldom precise. When the plankton is the main source of food, the ponds are generally made deeper for better growth of phyto- and zooplanktonic organisms. In ponds, plankton grcwth can be enhanced by fertilization and water management. The production and maintenance of the benethic algal complex involves considerable skill and attention.

A. Pond Preparation

The preparation of the ponds starts about two months before the fry are introduced. The ponds are drained completely during low tides. The bottom is levelled, raked with a wooden rake or ploughed to bring the sub-surface soil nutrients to the surface and to eradicate weeds. The pond bottom is levelled in such a way that it slopes gradually towards the deepest portion of the pond at the sluice gate. Often a shallow diagonal canal is made from the gate to the opposite corner to serve as a refuge for fry and fingerlings during hot days, and to facilitate transfer or harvesting of the stock. The pond is then dried and exposed to the sun for two or three days until the layer of surface soil cracks, after which some water is let in. Inorder to get rid of any predatory fish or other pests burrowing in the mud, this process of draining and drying may be repeated a few times. Besides eradicating pests and predators, drying also helps in the mineralization of organic matter in the soil. The water gates of the pond are protected with fine-meshed screens to prevent the entry of fish or other organisms from outside.

The ponds are then treated with poultry manure at the rate of 2 tons/ha. Water is let in just to cover the pond bottom. After 2 or 3 days, 150 kg/ha of 16:20:0 NPK fertilizer, or half that quantity of 18:46:0 NPK fertilizer per ha are added. In order to speed up the breakdown of chicken manure, urea may be added at the rate of 25 kg/ha. Within a week lablab growth starts. The water level in the pond is then gradually increased to 25-30 cm in a period of 1 to 1 1/2 months, increasing the level by 3-5 cm each time. Sudden increase in water level can result in detachment of lablab from the bottom.

B. Lablab Maintenance

The maintenance of this benthic complex requires proper *water management and grazing levels*. If overgrowth of the complex occurs, it has to be controlled by additional stocking of fry. Detached lablab is not allowed to accumulate and disintegrate in the ponds, and is removed and dried for later use as feed for milkfish. Organisms that feed on or disturb the growth of lablab are detected and eradicated as far as possible to maintain the algal pasture at an optimum abundance. Further applications of NPK fertilizers are made, if necessary, at intervals of 1 to 2 weeks to maintain the growth of lablab.

Lowering the salinity in the ponds by admixture with freshwater induces the growth of filamentous algae, which are known in the Philippines as 'lumut'. This is avoided, not only because the fry are not able to feed on them, but also they become entangled in the filaments.

C. Plankton Maintenance

If the fry are to be reared on plankton, the pond water is maintained at a depth of 75-100 cm, and chemical fertilizers are applied at the same rate as for lablab growth. In a few days plankton develops and the visibility underwater is about 15 – 40 cm. In case of an excessive growth of plankton, fertilization is not suspended but a part of the pond water is replaced.

D. Fry Stocking and Acclimatization

The density of fry in the nurseries is generally 30 – 50/m². Fry can be stocked directly in the nursery ponds if the salinity of the water in which they are transported is approximately the same as the salinity of the pond water. If there is a difference of over 5 ppt, fry should be acclimatized before transfer.

E. Nursery Pond Management

Nursery pond management involves the maintenance of suitable conditions for the growth of fry and its natural food (lablab). Inorder to avoid salinity increases during the summer months, some exchange of water may be needed. It is reported that the growth of milkfish fry is retarded at salinities above 45 ppt. Favourable temperatures for growth are above 23°C. If the growth of natural food is not adequate for the stock, artificial feeds like rice bran or dried lumut are provided. In about 1 1/2 to 2 months, the fry grow to a weight of 1-3 g and are then either stocked in rearing/production ponds or transferred to transition or stunting ponds.

F. Transition Pond Management

The transition or stunting pond, as the name implies, is meant to hold the fingerlings in a stunted condition for stocking later, during the off-season for fry. The stocking density in the transition ponds is about 10-15 fingerling/m^2, and they subsist on lablab or plankton for 1 to 2 months. Fertilization may be carried out to increase natural food production, but this may not be enough to keep the fish in a healthy but stunted condition. If the fingerlings have to be held for prolonged periods (upto 6 months or more) or if they become too thin, supplementary feeding with rice bran at the rate of 5% of the body weight daily may be given.

G. Wintering Pond Management

In Taiwan, where over wintering of fry is required, the fry are kept in shallow (20-40 cm deep) ponds with 1.5 m deep wintering ditches protected on the windward side by windbreaks of thatched bamboo frames. For producing stunted fingerlings, fry are stocked at the rate of 300,000 – 500,000/ ha and fed with benthic algae and rice bean, peanut meal or soybean meal. These wintering ponds may also be used for over-wintering under-sized fish from the previous harvest.

3.3.7. GROW-OUT

Basically, each farm has nursery, transition and rearing/production ponds, which can be independently drained or filled through a canal system. As mentioned earlier, Taiwanese transition ponds are also used as wintering ponds. The rearing/production ponds generally form 85 – 90% of a farm, and in modern farms where intensive culture systems are employed, each pond measures about 4-5 ha. Usually they are rectangular in shape and located on either side of the canal system for water supply and drainage.

A. Pond Preparation

The overall configuration and operation of the production ponds are very similar to those described for nursery ponds. Majority of farms depend on the production of benthic organisms for raising milkfish, and so basically the same pond management methods are followed. Even though in pen culture in eutrophic lakes milkfish have been grown to market size on plankton, in actual practice, the farmers have not yet been able to obtain consistent results with plankton feeding in pond culture.

In the early days of milkfish farming in the Philippines, lumut or the algal complex dominated by filamentous algae such as *Chaetomorpha, Cladophora* and *Enteromorpha* was considered to be the best natural food to be raised in pond. Later it was observed that *Chaetomorpha* are too coarse and fibrous to be suitable food for milkfish fingerlings and it is only the decaying algae in the detritus that the fish are able to utilize. Because of this, ponds with lumut growth can be stocked with only 1000 – 1500 fingerlings/ha and the yield expected would be only 200 –300 kg/ha/crop. Experience seems to indicate that lablab is also the best natural food for growing milkfish to market size. Fertilized ponds with good growth of lablab can yield 500-700 kg/ha/crop in a period of 2-3 months.

Procedures for preparing rearing ponds are generally the same as for nursery ponds. The ponds are drained and the bottom dried. If required, the soil p^H may be adjusted by the application of lime. Initial fertilization is done with a combination of organic and inorganic fertilizers. After the ponds are stocked, fertilization with urea and NPK fertilizer is continued at about half the initial dose at fortnight intervals taking care to exchange the water regularly.

B. Fish stocking

In traditional milkfish ponds stocking is carried out with milkfish only but during the course of culture other species especially grey mullets, shrimps (mainly *Penaeus* and *Metapenaeus* spp.) gain access converting it into a polyculture system. Stocking density is left to chance. However, in recent times, with the increased demand for and price of shrimp, milkfish farmers are undertaking deliberate stocking of penaeid shrimps and in some cases even converting milkfish ponds into shrimp ponds. The combination of milkfish with shrimps is not entirely based on compatible feeding habits, as there is obviously some overlap.

In view of the fluctuations in the benethic growth, the success of milkfish production in ponds is largely dependent on the timing and efficiency of stocking. Consequently, a number of systems have been developed for better utilization of the food resources and increased yields in milkfish ponds. The simplest system is to stock rearing ponds at the rates that the food resources can sustain, and harvest them when they have reached the marketable size. Since marketable size can be reached in 2 to 4 months, 3 to 4 crops can be raised every year if fingerlings are available. The usual practice is to stock a single size group of fingerlings (10-15 cm) at the rate of about 2000/ha, and completely harvest when they have grown to marketable size. The main disadvantage of this system is that there is a wastage of food when the fish are small, as they can not utilize all the food produced, and when they have grown the food produced in the pond may be insufficient because of the increased food requirements of the larger biomass.

Inorder to avoid shortage of food at critical times in rearing ponds, a procedure known as the "progression method" is practised by many farmers in the Philippines (Fig 000). Rearing is carried out in two stages. The fingerlings grow for a certain period in one pond and are then transferred to another pond where they grow to the market size. The food resources in both the ponds are not exhausted and several crops can be raised through proper management. This method has been further improved to a so-called 'modular-method', which involves a 3-stage rearing. Three contiguous ponds form a series, progressively increasing in size at a ratio of 1:2:4. The first pond is stocked at a density of 15000/ha. After about 6-7 weeks the stock is transferred to the second pond, and after about 4-5 weeks to the third pond, until they reach market size. As soon as a pond is emptied, it is prepared to receive the next stock.

A more intensive system of stocking is developed in Taiwan. It consists of stocking different size groups and repeated selective harvesting, and this is sometimes referred to as the "multi-size stocking method". Initial stocking may be with 3 size groups; e.g., 3000 fingerlings of average length 5 cm, 2000 of 15 cm length and 2000 of 18 cm length. Subsequent stocking may be with smaller fingerlings (5 cm length) at about 1-2 months intervals, at the rate of 2000 – 3000/ha each time. Repeated selective harvesting is performed 3 to 5 times to remove the market sized fish.

C. Feeding and Pond Management

As milkfish farming is largely based on the production of natural food, artificial feeding is provided only when the natural food is not adequate. Locally available feedstuffs (or conventional feeds) like rice bran, peanut meal and soybean meal are used for supplementary feeding.

An important aspect of pond management consists of reducing or eradicating organisms that disturb or feed on benthic growths in ponds. Chironomid larvae, polychaete worms and snails are the most common pests. Taiwanese farmers use different types of pesticides to eradicate them. The application of lime and urea for the initial preparation of milkfish ponds usually helps to reduce the growth of these organisms.

D. Diseases

There are very few known diseases of milkfish. *"Catching cold"* is a condition when there is a sudden drop of temperature in shallow ponds. The symptoms are a milky discoloration of the skin and sluggish movements. After 2 or 3 days portions of skin may drop off. No mortality has been observed.

3.3.8. PEN CULTURE

Pen culture of milkfish is practised in the eutrophic lakes of the Philippines, especially in Laguna de Bay. Most of the pens are enclosed by synthetic netting of suitable mesh size, installed on a framework of bamboo poles dug deep into the lake bottom. The size of the pens varies considerably from 1.5 to 100 ha. The most common size appears to be between 10 and 20 ha. When fingerlings have to be reared on site, a nursery pen is constructed within the rearing pen. It is made of smaller meshed netting and usually measures around 20 m x 20 m with a depth of atleast 1.5 m.

The stocking rate depends on the density of planktonic blooms in the lake. Generally it varies between 10,000 and 20,000 fingerlings/ha in the main pen and 100 fry/m^3 in the nursery pen. Supplementary feeding is provided in the nursery and it may take upto one month for the fry to grow to fingerlings of about 20g size. Fingerlings stocked in the rearing pen feed on natural food in the lake and no artificial feed is provided. Multiple stocking and harvesting can be practised in pens, as in ponds, if there is a dependable supply of fingerlings. Depending on local conditions, it may take 4 to 5 months for the fingerlings to reach marketable size in pens.

One of the major harzards in such eutrophic lakes is the occurrence of fish kills due to anoxia caused by death and decay of algal blooms.

3.3.9. HARVESTING AND MARKETING

Harvesting methods depend on the rearing techniques and the design of the farm. When thinning of stock during the culture period is involved or when multiple stocking and harvesting is practised, it is necessary to use gill or seine nets. Fish caught by gill nets are likely to be bruised and may loose some scales. The price of such fish in the Philippine markets is low. Even the fish harvested by complete draining of ponds do not command a good price in the Philippines, because the mud adhering to the fish is believed to impart a muddy flavour or taste. This is why milkfish pond farms in this country have special catching ponds. To harvest the fish, the rearing pond is partially drained at low tide and at subsequent high tide the water is allowed to flow in through the catching pond. The fish swim against the current and enter the catching pond, from where they are easily gathered with seines or scoop nets. Some farmers use electrical fishing equipment for harvesting.

Taiwanese farmers use large gill nets for harvesting milkfish ponds along with a scare-line to empty the stomachs of the captured fish. Milkfish with empty stomachs keep better during transport to markets. At the end of the rearing season, the ponds are drained after netting and the remaining fish picked up.

Special care is taken in handling milkfish in the Philippines because of consumer preference for unbruised fish with scales intact. The fish are often dipped in iced water before packing to prevent loss of scales during handling. Most of the fish are sold in fresh condition, but there is also an important market for deboned and smoked fish.

Economic data on intensive mono and polyculture of milkfish revealed that higher returns are obtained in polyculture with quick growing species of shrimps.

3.3.10. SUMMARY

1. *Chanos chanos* commonly called milk fish or white mullet is a well known marine fish of Indo-pacific region. It is a euryhaline and fast growing food fish suitable for culture in brackishwater ponds.

2. Indonesia, the Philippines and Taiwan are the major milkfish producing countries followed by few other Asian countries including India. Much of the brackishwater aquaculture experience in Asia has originated from milk fish farming.

3. Milk fish are herbivorous and detritus feeder. It is a highly euryhaline fish that can be cultured both in brackishwater and freshwater bodies. It can tolerate temperatures between 15^0 and 40^0C and low oxygen levels.

4. It has no capture fishery importance but its importance is based on the large-scale farming in over 400,000 ha of coastal impoundments in Southeast Asia. The average production in Taiwan is 2 t/ha, in the Philippines 600 kg/ha and in Indonesia 300 kg/ha.

5. In India, milkfish culture is taken up in the states of West Bengal, Kerala, Tamilnadu and Andhra Pradesh. The production in traditional culture is less than 500 kg/ha/year whereas in semi-intensive farming, it ranges from 2000 to 4000 kg/ha/year.

6. The most common culture system for milk fish is the brackishwater coastal pond farms. Milkfish are sometimes grown in freshwater ponds or stocked in lakes and reservoirs. The familiar milkfish farming in freshwaters is the pen farming in the lakes of Laguna de Bay and lake Sampaloc in the Philippines.

7. Milkfish spawn in the sea near the coast. Small larvae (12-15 mm) occur periodically along the sandy coasts and in the estuaries. The season for collection varies in different regions. The fry are collected by using dip nets, scoop nets, seines, drag nets and traps. The captured fry are transported to ponds by means of earthen-ware jars or plastic bags or flat bamboo baskets.

8. Milk fish can be induced to spawn by hypophysation using carp pituitary homogenate, semi-purified Salmon Gonadotropin and HCG. Generally only females are hypophysed. The fecundity is estimated to be 2 million/kg body weight.

9. The fertilized eggs can be hatched in saltwater (30-34 ppt) in 25-29 hrs at 26-30°C. The post larvae fed on live food and prepared food can grow to 15 mm in 20 days.

10. Separate nursery and transition ponds are required for rearing the fry to fingerling stage. The fry feed on rich growths of benthic biological complex called lab-lab maintained in the nursery ponds. In recent years, many farmers have adopted the practice of developing plankton in ponds as food for milk fish fry.

11. Pond preparation includes ploughing and levelling of bottom with a shallow diagonal canal and a gradual slope towards the deepest portion of the pond at the sluice gate. The pond is then allowed to sun dry for 2 or 3 days after which some water is let in and drained. This process of draining and drying may be repeated if predators or pests burrow in the mud. Then the ponds are treated with organic and inorganic fertilizers to develop lablab.

12. Lablab should be maintained properly in the pond by water management, by stocking more number of fry in case of excess growth, and by eradication of organisms that feed on lablab. Low salinity in the nursery pond leads to the development of undesirable filamentous algae called 'lumut'.

13. If plankton is to be developed in the pond, water level should be maintained at 75 to 100 cm. Fertilization is same as that applied for lablab growth.

14. In nurseries, fry are stocked at the rate of 30-50/m^2. Before stocking, they should be acclimatized for pond water.

15. Post-stocking nursery pond management involves the maintenance of water quality, natural food and provision of supplementary feed. In about one and half to two months the fry attains 1-3 g. Then they are stocked either in rearing ponds or in transition ponds. In Taiwan, the fry are stocked in wintering ponds during winter for over wintering.

16. The overall configuration and operation of the rearing/production ponds are very similar to those described for nursery ponds. In grow-out a number of fish stocking systems have been developed for better utilization of the food resources and increased yields of milkfish. In the simplest system, the fingerlings are stocked (2000/ha) at a time and harvested when they reach marketable size. The disadvantage of this system is that there is a wastage of food when the fish are small and insufficient when they grow to larger size. In 'progression method' rearing is carried out in 2 stages i.e. in two types of ponds. The improved 'modular method' involves 3-stage rearing. A more intensive method is 'multi-size stocking method' which involves stocking different size groups and repeated selective harvesting of market sized fish.

17. In milkfish ponds, artificial feeding with conventional feeds is provided only when the natural food is not adequate. Pond management mainly involves the eradication of pests which disturb or feed on the lablab. 'Catching cold' is the common problem when there is a sudden drop of temperature in ponds.

18. Pen culture of milkfish in the eutrophic lakes of the Philippines is popular. Pens are enclosed by synthetic netting of suitable mesh size, installed on a frame work of bamboo poles dug deep into the lake bottom. Common size of a pen is 10 to 20 ha. When fingerlings have to be reared on site, a nursery pen is constructed within the rearing pen. Stocking rate varies between 10,000 and 20,000 fingerlings/ha in the main pen and 100 fry/m^3 in the nursery pen. Fishes feed on natural food in the lake. Fingerlings reach marketable size in 4 to 5 months.

19. In the Philippines, harvesting is carried out in special catching ponds with seines or scoop nets. Some farmers use electrical fishing equipment. Taiwanese farmers use large gill nets for harvesting. Special care is taken in handling the fish. Most of the fish are sold in fresh condition, but there is also an important market for deboned and smoked fish. Polyculture of milkfish and shrimps rather than monoculture is found to be more profitable.

3.3.11. MODEL QUESTIONS

1. Give an account of the culture of milkfish, *Chanos chanos*.
2. Describe the various steps in rearing the fry of milkfish.
3. Write notes on
   a. Collection and transport of milk fish fry.
   b. Lablab and lumut
   c. Fish stocking systems in grow-out of milkfish.
   d. Pen culture of milkfish.

3.3.12. REFERENCE BOOKS

Jhingran, V.G. 1991. *Fish and Fisheries of India.* Hindustan Publishing Corporation (India) Delhi.

Pillay, T.V.R. 1990. *Aquaculture Principles and Practices,* Fishing News Books, Ltd., Oxford.

Dr. P. PADMAVATHI

UNIT – I

LESSON - 1.5

BUNDH BREEDING AND INDUCED BREEDING (HYPOPHYSATION) OF CARPS

1.5.1. Objectives
1.5.2. Introduction
1.5.3. Bundh Breeding of Carps
  A. Types of Bundhs
    i). Wet bundhs
    ii). Dry bundhs
  B. Topography
  C. Improved Bundhs
  D. Fish breeding techniques
  E. Spawning and fertilization
  F. Factors influencing spawning
  G. Collection and hatching of eggs
1.5.4. Induced breeding (Hypophysation) of carps
  I. Induced breeding in Indian major carps
    A.Fish pituitary gland
    B.Collection of pituitary gland
    C.Preparation of pituitary extract
    D.Selection of breeders
    E.Dosage and injection of pituitary extract
    F. Spawning/Breeding
    G. Hatching
    H. Induced breeding with other substances
    i) HCG
    ii) Ovaprim
    iii) Ovatide
  II. Induced breeding in Chinese carps
  III. Induced breeding in Common carp
1.5.5. Summary
1.5.6. Glossary
1.5.7. Model questions
1.5.8. Reference Books

1.5.1. OBJECTIVES

The purpose of this lesson is to describe the scientific methods of breeding the cultivated carps in confined waters such as

* breeding fish in bundh-type tanks, and
* breeding fish through hypophysation technique.

1.5.2. INTRODUCTION

The amount of fish seed collected from natural resources is not sufficient to meet the growing demand of fish culture. The seed collected from natural resources is generally a mixed lot, and may include uneconomic and even predatory forms. Further, the identification and isolation of desirable seed from the mixed lot and their transportation to ponds or markets become difficult. Thus the availability of pure seed in required number is a big problem in natural collections. Therefore, fish seed production by artificial methods has been contemplated for quite sometime by enthusiastic fishery biologists. As a result of their striving efforts, production of fish seed under controlled conditions has become possible in few species of carps and some other varieties of fish.

Major carps are known to breed naturally in rivers. They also breed in artificially constructed water bodies which are popularly known as '*bundhs*' where fluviatile (riverine) conditions are simulated during the spawning season. In confined waters (ponds) though the Indian major carps and Chinese carps grow rapidly and attain sexual maturity, they do not breed there and need inducement for breeding. If these matured breeders are transferred from confined waters to semi-confined rain-fed ponds or bundhs, where the pond bottom is of muddy nature, the fish breeds whenever there is a good rainfall and a drop in temperature of water. Carps are also induced to breed artificially by hypophysation technique which helps to produce pure quality seed of a selected fish species in large quantities. Hence in modern pisciculture practice, induced breeding technology has occupied a prime place. The following sections deal with the production of fish seed by bundh breeding and induced breeding technology.

1.5.3. BUNDH BREEDING

Bundhs are special type of perennial and seasonal tanks or impoundments. During monsoon periods riverine conditions are simulated in these tanks with excess water flowing out through the outlets. Therefore, they form a sort of breeding ground for the major carps under certain conditions. Bundhs are more commonly seen in the districts of Midnopore and Bankura in West Bengal and around Nowgong in Chhattarpur district in Madhya Pradesh and in Bihar. The bundhs, after a heavy shower, receive large quantities of rain water with washings from their extensive catchments and provide large shallow marginal areas which serve as breeding grounds for the fish.

A. TYPES OF BUNDHS

Bundhs are of two types *viz,* perennial bundhs or *wet bundhs* and seasonal bundhs or *dry bundhs.*

i) Wet Bundhs

The wet bundh is a perennial pond located on the slope of a vast catchment area of undulating terrain with proper embankments having an inlet towards the upland or catchment area, and an outlet at the opposite lower end. During summer only the deeper portion of the pond retains water containing major carp breeders. The remaining portion is dry and may be used for agriculture. After a heavy rain, freshwater from the catchment area rushes into the bundh in the form of streamlets, locally known as *dhals* in Midnapore. The major portion of bundhs gets submerged with water and the excess water flowing out through the outlet known as *bulans*. The shallow areas of bundhs, where fish actually spawn, are called *moans*. The fish starts spawning in such a stimulated natural condition in the shallow areas of a bundh. The outlet is protected by a bamboo fencing known as *chhera* to prevent the escape of breeders. The flow of water through the outlet can be controlled by blocking the fencing with straw and mud. The wet bundhs are comparatively much bigger in size than the dry bundhs.

ii) Dry bundhs

A dry bundh is a shallow depression enclosed on three sides by an earthen embankment, which impounds fresh rain-water from the catchment area during the monsoon season. Bundhs get flooded during the monsoon, but remain completely dry for a considerable period during the remaining part of the year. These are seasonal rainfed water bodies, and hence known as seasonal bundhs. Selected breeders are released into the bundhs when they get flooded during the monsoon period. Dry bundhs yield 100% pure seed of selected species on large scale.

B. TOPOGRAPHY

The topography of the land has a great role to play in the location and distribution of the dry bundhs. It is preferred to have undulated land because it provides a large catchment area and facilitates quick filling of the bundh even with a less rain, and at the same time quick and easy drainage due to gravitation. In West Bengal, a catchment area of more than five times the bundh area is considered most suitable whereas in Madhya Pradesh a ratio of 1:2.5 is considered essential. In Bankura district of West Bengal, most of the dry bundhs are fed with water from storage tanks, constructed in the upland area. In general, a water shed with more than fifteen hectares of hard land for every hectare of water surface in the pond is considered essential. If the soil is retentive in nature, then forty hectares of watershed for each hectare of surface water is a better proposition. The fields must not erode. If the water shed is found either too big or too small even then it may be possible to correct the situation by using diversion terraces. If water is more, excess watershed may often be cut off and the water disposed off elsewhere. If more water is needed, a diversion terrace will increase the effective watershed.

The embankment must be constructed at the low level side. A spillway and sluice are a must in the bundhs. The spillway or flood outlet is a surface drainage way that will carry surplus water during heavy rains. It must be placed around one end of the dam in hard ground. When required the pond can be emptied completely with the help of sluice gates. Spillway and sluice should be provided with strong iron netting so that the fishes may not escape from the breeding bundh. Once the bundhs are constructed, they can be used for many years.

C. IMPROVED BUNDHS

Since major carps generally breed almost at any place in the shallow bundhs, it may be advantageous to prepare spawning grounds at different levels so as to get them flooded at different water levels in the bundh. But, it is necessary to have the spawning ground away from the direction of the current.

The most modern constructions are generally masonry structures with arrangements of a sluice gate in the deepest portion of bundh for complete drainage and one or two waste weirs for overflow of excess water. In most cases, apart from the bundh itself, a dry bundh unit consists of a few storage ponds for stocking breeders, an observation unit or post with arrangement for storing necessary equipment and a set of cemented hatcheries (measuring 2.4 m x 1.2 m x 0.3m) with a regular supply of water for handling a large number of eggs at a time. In some cases, the embankment is a pucca stone masonry with a small sluice gate and a portion of the embankment itself serves as the waste weir.

Recently at Mogra, West Bengal, the farmers have created a cement pond of about 75' x 25'. The bottom of the pond is pucca, but divided into two portions possessing a gradual slope. When water is filled into the pond, the first part possesses about one meter depth of water and lower one has about 2 m depth. The owners called it as West Bengal bundhs. The bottom is filled with 6 inches of fine river sand. Before releasing them into the pond, the male and female breeders are partially hypophysed.

D. FISH BREEDING TECHNIQUES

Breeding in both wet and dry bundhs usually occurs after continuous heavy showers for days, when large quantity of rain water rushes into the bundh. Catla, rohu, mrigal, common carp, silver carp and grass carp are used to breed in bundhs.

The brooders are collected in May and the males and females are stocked in separate storage tanks till the first monsoon showers. As soon as water accumulates in the bundhs, a selected number of these breeders are introduced into these bundhs and a constant vigil is maintained. In the olden days no importance was given to maturity, sex ratio, etc. The techniques were improved later and the breeding was done with a better understanding of sex ratio and number of breeders. Thus a selected number of fully ripe females and males of major carp breeders in the ratio of 1 female to 2 males (1:1 by weight) are introduced into the bundhs on rainy days. At first, smaller–sized fish get stimulated to breed and, in order to spawn, migrate either to the shallow areas of the bundh itself or to those adjoining it. Bigger fishes spawn next in the same area. Spawning occurs over hard or sandy soil and even on rocky embankments.

In modern techniques, few pairs of females and males i.e. 10 to 20% of the brood stock introduced for spawning in a dry bundh are being injected with either pituitary extract, or HCG or ovaprim and released into the bundhs. It has been experienced that the induced breeding by this technique in dry bundhs results in complete spawning of the entire brood stock. This type of "sympathetic breeding in dry bundhs" has been used in West Bengal. By this method of partial hypophysation all the limiting factors for spawning like rain, thunder, storm and current of water can be bypassed. Thus the structure of the bundhs has also undergone some changes in that instead of collecting fresh rain water in the bundh proper, the water is now stored in a reservoir located at a higher elevation. A series of small bundhs with inlets and outlets are constructed below the reservoir. The bundhs can thus be filled with rain-water as and when desired and breeding operations undertaken without waiting for the bundh to be filled afresh with rain-water.

In dry bundhs, Catla, being a deep-bodied fish, reaches the breeding ground and breeds in deeper areas when the rain fall raises the depth of water to 1m or more. When compared to catla, rohu and mrigla breed in relatively shallow waters varying in depth from 0.5 to 1 m. In wet bundhs, the brood stock may be maintained throughout the year or replenished prior to the monsoons. The brooders are generally not injected with pituitary extracts but are stimulated to breed due to the current of rain water from the catchment area, like in the case of dry bundh breeding.

Both grass carp and silver carp have also been reported to breed naturally in dry bundhs without stripping. Thus dry bundhs are considered to be one of the reliable means for mass breeding of chinese carps to meet the increasing demand of their seed.

E. SPAWNING AND FERTILIZATION

The courtship of male and female is short-lived. The coiling of the two partners exerts pressure on the abdomen of the mating pair, resulting in the release of ova and milt. The extent of extrusion of ova and milt depends upon the rush of water into or out of the bundh; the greater the rush, the more complete the extrusion. Eggs are laid at different places and times during which the pair keeps on moving.

Fertilization in major carps is external. The fertilized eggs are abandoned by the parents and they are either drifted to the edges of the bundh or get washed down the *nullah*. When spawning is over, a thick blanket of eggs is left behind on the spawning site.

F. FACTORS INFLUENCING SPAWNING

No single factor can probably be attributed to spawning of major carps in rivers and bundhs. The act of spawning involves the completion of a chain of interrelated pre-conditions. Heavy monsoon flood and inundated shallow spawning grounds stimulate spawning. Temperature between 22 and 33^{0}C and cloudy days accompanied by thunder–storm and rain may also influence spawning of the carps.

G. COLLECTION AND HATCHING OF EGGS

Soon after spawning is over, the eggs are collected from bundhs with a gamcha type of nets and released into improvised hatching pits or double-walled hatching hapas or cement hatcheries. Collection of all the eggs is impossible, especially in case of wet bundhs, due to its larger areas. About 70% of eggs can be collected from bundhs. A double-walled hapa, which is fixed in the bundh itself, consists of a bigger outer hapa made of ordinary cloth and an inner smaller hapa made of round meshed mosquito netting. These hapas are laid in such a way that the inner having a water depth of 20 to 30cm. The eggs are released into the inner hapa. After hatching, the hatchlings pass out of the inner hapa into the outer, and are retained there for three days till they become ready to feed on external food. In West Bengal, the eggs are kept for hatching in specially dugout small earthen pits with mud plastered walls. After 12 hours the hatchling are transferred to large earthen pits. The spawn survival rate in hapa hatcheries is 32-35% while in cement hatcheries as much as 97% has been attained. A cement hatchery has more capacity than a double-walled hapa and is far more economical than the hapa.

1.5.4. INDUCED BREEDING (HYPOPHYSATION) OF CARPS

The practice involved in prompting the fish to breed in confined waters is known as induced breeding. Chiefly induced breeding involves hypophysation technique which includes the injection of pituitary extracts to the ripe gravid fishes to spawn. The concept of the application of pituitary injections for successful spawning of fish is due to Houssay (1930) of Argentina. The technique was first employed by the Brazilians (Von Ihring and others) as early as 1934. Later the Russians succeded in developing the technique in the year 1937. India was the third country to use this technique successfully in Indian major carps in 1957 and Chinese carps in 1962. In this technique, injection of pituitary extract of the same species or related species is given to the prospective breeders which respond favourably and spawn within a short interval of time.

In India, the first attempt of induced breeding was made by Hamid Khan in 1937 in mrigal by using mammalian pituitary hormones. Chandhuri (1955) was the first to successfully induce a smaller carp, *Esomus danricus* to breed by introperitoneal injection of catla pituitary gland extract. Ramaswamy and Sunderaraj (1956, 1957) obtained similar results in catfishes. The first success in induced breeding of Indian major carps through hypophysation was achieved in 1957 by H.L. Chaudhuri and Alikunhi at CIFRI, Cuttack.

I. INDUCED BREEDING IN INDIAN MAJOR CARPS

A. FISH PITUITARY GLAND

It is small, soft and white in colour and more or less round in carps. It lies on the ventral side of the brain behind the optic chiasma in the concavity of the floor of the brain-box, known as sella turcica. In few fishes it is attached to the brain by a short thin stalk, known as the infundibulum. Based on the presence or absence of stalk, the glands are classified into two types namely i) platybasic – without stalk as in Channidae and Nandidae and ii) leptobasic – with stalk as in Cyprinidae (carps). The size and weight of the gland varies according to the size and weight of the fish. In *Labeo rohita*, the average weight of the pituitary gland ranges from 6.6 mg in 1-2 kg fish to 18.6 mg in 4-5 kg fish.

Pituitary gland secretes growth hormones, gonadotropic hormones, thyrotropic hormones and adrenocorticotropic hormones. Of these, the hormones related to reproduction and spawning of fish are gonadotropic hormones such as Follicle Stimulating Hormone (FSH) and Luteinizing Hormone (LH). Both hormones are secreted throughout the year, but the proportion in which they are secreted is directly correlated with the cycle of gonadal maturity. The **FSH** causes the growth and maturation of ovarian follicles in females, and spermatogenesis in testes of males. **LH** promotes release of gametes from nearly ripe gonads and stimulates the appearance of secondary sexual characters. These hormones are not species specific, i.e., a hormone obtained from one species is capable of stimulating the gonads of another fish. However, there is great variability in its effectiveness in different species. Experiments on induced breeding of fish revealed that fish pituitary extracts are relatively more effective than mammalian pituitary hormones, sex hormones and various steroids. This is the reason why fish pituitary is being extensively used today in fish breeding work all over the world.

B. COLLECTION OF PITUITARY GLAND

The glands are collected from mature fish during their spawning season either from freshly killed fish or from fish preserved in ice for 10 days. The success of the hypophysation technique depends upon the quality of the donor and the recepient fish. The fish pituitary of one species is also active in another species. There is no difference between the pituitary of male and female donor fish.

The glands are removed from the fish head by cutting the skull with a sharp butcher's knife or a hand saw. When the pituitary glands are collected, they can be used immediately or preserved in airtight dark coloured phials containing absolute alcohol for dehydrations and stored either at room temperature or in a refrigerator. The preservative should be changed several times for further dehydration and defattening of pituitary glands. Alternately, they may be frozen or dried in acetone. Acetone–dried carp glands have been found to be viable for about 10 years.

C. PREPARATION OF PITUITARY EXTRACT

At the time of injection of breeders, the preserved glands are dried in a filter paper and weighed. Generally a fish pituitary gland weighs about 5-10 mg. Then the required quantity of glands are taken and macerated with a tissue homogenizer either in distilled water or 0.3% saline. Further dilution is usually made with the same fluid. The gland suspension is then centrifuged and the supernatant fluid drawn into a hypodermic syringe for injection. Usually the volume of the extract to a fish does not exceed 1 ml.

To avoid the risk of preparing pituitary extracts every time before injection afresh, the extract can be prepared in bulk and preserved in glycerine (one part extract and two parts glycerine). The glycerine–preserved extract is found to retain its potency for 2 months at room or under low temperatures. The advantage of this method is that it permits hormone extraction from a large number of glands at a time, ensuring uniform hormone potency per unit volume of extract and saving time in the preparation of injection dose. The various items used in the preparation of pituitary extract are shown in Fig. 1-25.

D. SELECTION OF BREEDERS

Healthy breeders are required for successful breeding. The male and female breeders are selected and stocked separately in a fertilized pond at the rate of 1,000 to 2000/ha, a few months before the actual breeding. During this period, they are fed on groundnut oil cake and rice bran in the ratio of 1:1 at the rate of 1-2% of the body weight of the fish.

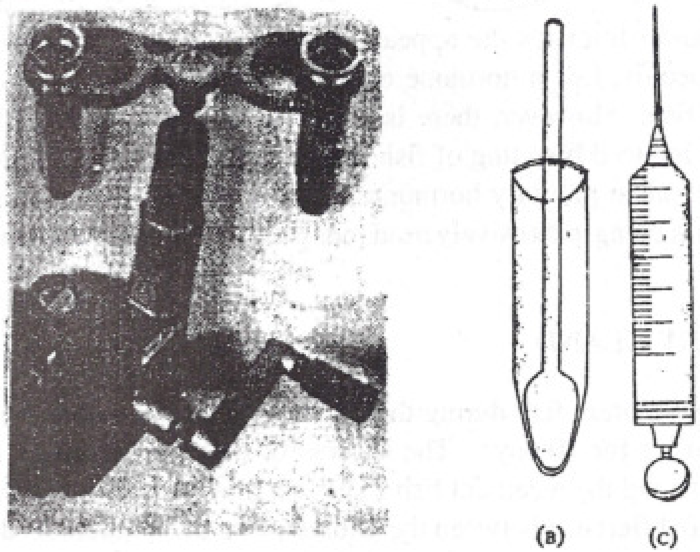

Fig. 1-25. Instruments for pltuitary gland extraction
a) Centrifuge b) Test tube for grinding (homogenizer)
c) Syrynge

Indian major carps, each weighing 1.5 – 5.0 kg are preferred for induced breeding. The males are identified by the roughness of the dorsal side of the pectoral fin especially during the breeding season. In the case of female the pectoral fin is smooth. Secondly, males often show oozing of milt in the vent on slight pressure on the abdomen. The ripe females have soft bulged abdomen and a swollen reddish vent. Such fishes are selected for breeding purposes. The breeders are to be carefully handled since injured breeders do not respond to pituitary injection.

E. DOSAGE AND INJECTION OF PITUITARY EXTRACT

The function of the pituitary extract depends upon the timely treatment and the phase of sexual cycle of the breeders. Pituitary extracts of the same species or of a different related species may be given. The former is called homoplastic and the latter heteroplastic.

The selected breeders are collected by hand nets and weighed. The breeders are wrapped in the hand net, placed on a soft cushion and then the pituitary extract is injected intramuscularly at the caudal peduncle or shoulder region near the base of the dorsal fin. Intra-peritoneal injections are preferred in USA and Japan and intra-cranial in USSR. However, the intra-muscular injection is less risky in comparison with the other methods. Volume of extract required is 0.5 to 2 ml for breeders weighing up to 10 kg. A 2 ml hypodermic syringe graduated to 0.1 ml division is generally used. Clinical needle No.24, 22 and 19 are used for breeders of <1kg, 1-3 kg and >3 kg respectively.

The dose of pituitary extract depends on the weight of the breeder and its stage of sexual maturity. The females are given two doses, *viz.*, a preparatory or provocative dose of 2-3 mg/kg body weight followed by a second dose called resolving dose of 5-8 mg/kg weight, 4-6 hours after the first dose. The males (two males per female, 1.5:1 by weight) are given only a single dose of 2-4 mg/kg body weight at the time of second injection to the female. Slight alterations in doses may be made depending on the stage of maturity of the breeders as well as on environmental factors.

F. SPAWNING / BREEDING

The injected male and female breeders are introduced into a *breeding hapa* in the ratio of 2:1 for spawning. A breeding hapa is a box–shaped rectangular cloth container (Fig.1-26) in the size of 3.5 x 1.5 x 1.0 m for larger breeders and 2.5 x 1.2 x 1.0 m for breeders less than 3 kg. All the sides of the hapa are closed except on one side at the top through which spawners are introduced or taken out. This opening is closed after the introduction of breeders into the hapa. The breeding hapa or a battery of hapas are fixed to bamboo poles in a pond, channel, river or any watershed. About 15 to 25 cm of hapa should remain above the water surface while its bottom should not touch the muddy pond bed.

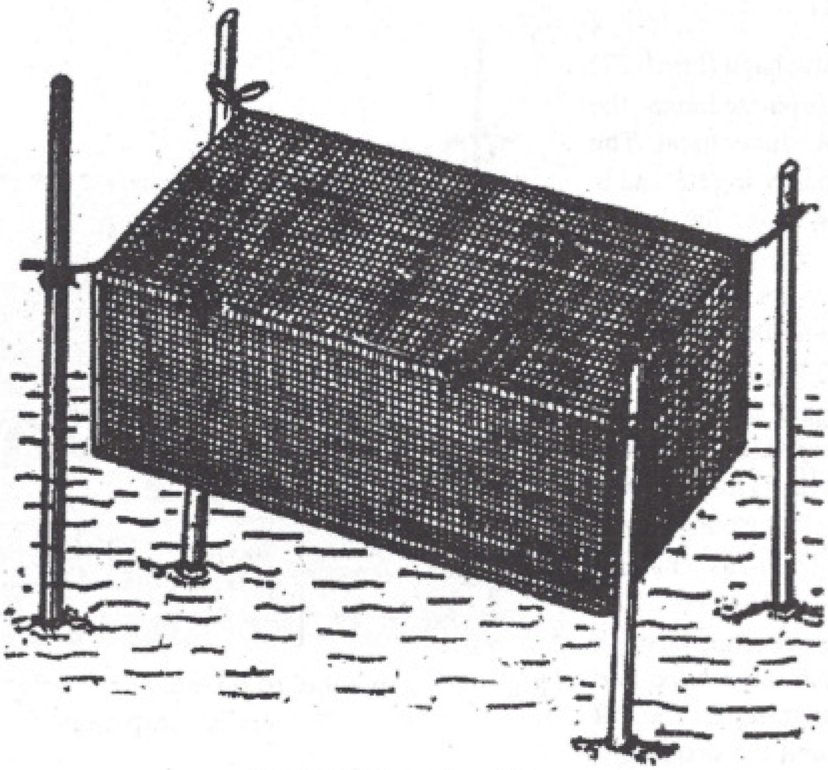

Fig. 1.26. Breeding Hapa

Instead of a breeding hapa, a small concrete spawning pond of 10x3x1 m can also be used. Such a pond should have proper inlet and outlet systems. A running water with a speed of 0.2 to 0.5 m/sec has been found to be ideal for stimulating the breeder to spawn.

The injected breeders in the hapa, after a brief period of courtship shed the ova and milt. The spawning normally takes place after 3-6 hours. Low temperature, rain water or showers and cool wealther influence the spawning. In the case of failures, a third dose can be injected to the females 10-12 hours after the second injection. After spawning, the breeders are removed from the hapa.

The Indian major carps could be induced to spawn either naturally or by hypophysation twice in the same season with an interval of two months. The breeders after the first spawning are fed with groundnut oilcake and rice bran in the ratio of 1:1 at 2-5 % body weight. When favourable climatic conditions occur, they mature and are ready for spawning.

The fecundity of the Indian major carps is very high, about 2-3 lakh eggs/kg body weight. The fertilized eggs are transparent and non–adhesive. The eggs measure 3-5 mm in diameter. In about 8-10 hrs the fertilized eggs get water hardened and swollen. The unfertilized eggs appear opaque which are to be discarded. The fertilized eggs after the embryos have commenced twitching movements, are transferred from the breeding hapa to a hatching hapa.

G. HATCHING

A hatching hapa (Fig.1-27) consists of two separate hapas, the outer hapa and the inner hapa. The inner hapa is smaller in size and is fitted inside the outer hapa. The inner hapa is made of round meshed mosquito net cloth (1.75 x 0.75 x 0.45 m) and the outer hapa made of cloth (1.8 x 0.9 x 0.9 m). The fertilized eggs (about 50,000) are uniformly spread on the bottom of the inner hapa. The hatching hapa is also fixed in the ponds using bamboo poles. The eggs hatchout in 15-18 hours at 26-30°c. The hatchlings (spawn) escape through the meshes of the inner hapa and swim into the outer hapa. The left over egg cases and the dead eggs in the inner hapa are removed. The hatchlings are left in the outer hapa itself for 3 days. During this period they subsist on their yolk sac. When the yolk is completely absorbed, the spawn are ready for stocking in the nursery ponds.

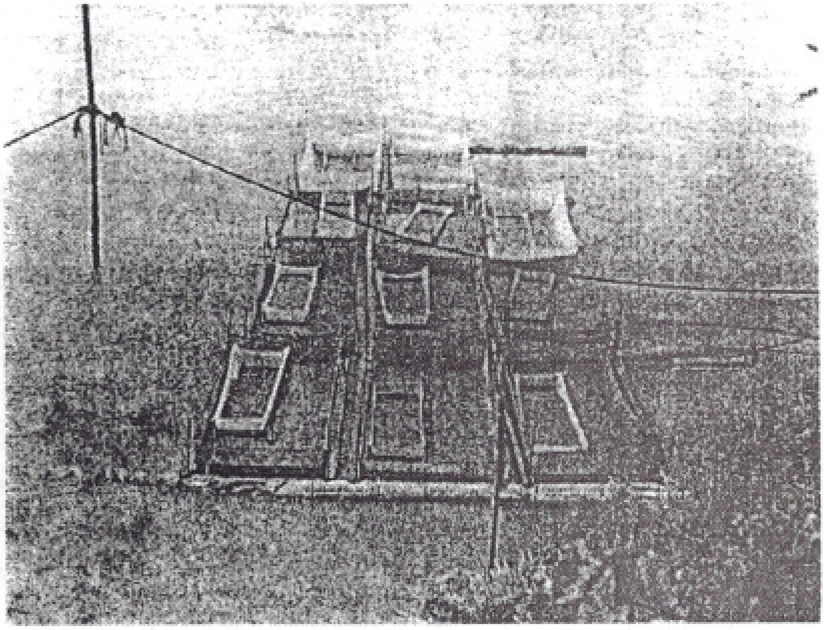

Fig. 1-27. A number of double hapas being used for hatching Indian carp eggs.

For hatching, the other devices used are jar hatchery and Chinese circular hatchery. Chinese circular hatchery has been widely used commercially for the large-scale production of fish spawn.

H. INDUCED BREEDING WITH OTHER SUBSTANCES

Pituitary gland extraction and injection is a well established technique for induced breeding of fish all over the world. The large scale use of pituitary glands poses many problems with regard to its availability and quality. Hence, the need for developing a substitute for fish pituitary injection is realized by modern pisciculturists.

i). H.C.G.

Human chorionic Gonadotropin (HCG) has been found as one of the alternatives for pituitary gland. H.C.G. is a glyco-protein or sialo-protein. The crude HCG is in powder form and greyish white or light yellow in colour. Its primary function is to maintain the production of oestrogen and progesterone by the corpus luteum. It is produced by the placenta and excreted through the urine of pregnant women during early stages of pregnancy (2-4 months). HCG is more or less similar in character and function to FSH and LH as present in pituitary gland. Hence, HCG can also be used for early ripening of gonads.

HCG has several advantages over pituitary gland. With HCG fish attains maturity faster and the span of the breeding season can be increased. HCG treated fishes can be used more than once for induced breeding in the same season. HCG ensures better survival of spawn, reduces the time gap between first and second doses, more economical and has a long shelf life. HCG is easily available and more reliable. Periodical injections of HCG as growth hormone throughout the year ensure better health, increase in weight and gonadal development. Potency of HCG is known (30 IU/mg). It is available in packets and there is no need of refrigeration. Consumption of the drug is less during induced breeding i.e. about 4 mg/kg body weight is recommended 1-2 months prior to breeding to both males and females.

Use of only HCG in the breeding of Indian major carps has not given successful results so far. A combination of 60-80% HCG and 40-20% pituitary gland for Indian major carps and grass carp is successful. In case of silver carp, use of HCG alone is found to be quite successful. The dosage for females is 6-8 mg/kg body weight as first dose and after 6-7 hours, 10-12 mg/kg body weight as second dose. For males the dosage is 4-6 mg/kg body weight.

ii) OVAPRIM

Though several hormones and synthetic formulations have been tried for induced breeding of fishes, their use in commercial seed production was not common till the development of "Ovaprim". The breakthrough achieved in isolating and characterizing the gonadotropin-releasing hormone (GnRH) from salmon led to development of a commercial product known as ovaprim by the Syndel laboratory, Canada. Many hatcheries are switching over from the use of pituitary gland to ovaprim due to its availability as ready-to use inducing agent (available as liquid in 10 ml vials), good breeding response and high percentage of ovulation and fertilization, besides requiring only one injection instead of two doses. The common dose for all carps is 0.10-0.20 ml ovaprim /kg body weight of males and 0.25-0.80 ml ovaprim/kg body weight of females. While the use of ovaprim has been accepted well by the farmers over the last few years, the high cost of the hormone compared to pituitary gland has remained a major constraint.

iii). OVATIDE

It is an indigenous, cost-effective and new hormonal formulation for induced breeding of fishes. The new formulation is having the base of a synthetic peptide which is structurally related to the naturally occurring hormone, gonadotropin releasing hormone (GnRH). GnRH is not a steroidal hormone and belongs to the class of organic substances called peptides. The common dose for all carps is 0.2-0.5 ml/kg body weight of females and 0.1-0.3 ml/kg body weight of males. It was reported to have the same advantages and give similar results as that of ovaprim, at almost half of the price. While the synthetic formulations were found to give considerably high breeding success, performance of seed produced through such products needs further evaluation.

Other substances like LH-Rh analogues, steroids and clomiphene are also used for induced breeding of fishes.

II. INDUCED BREEDING IN CHINESE CARPS

The silver and grass carps are known as the Chinese carps. They breed only in rivers. Normally they do not breed in ponds. However, the hypophysation techniques have been adopted to induce them to breed in confined waters. The methods of induced breeding are similar to those adopted for the Indian major carps. Both homoplastic and heteroplastic pituitary extract injections give good results. However, unlike the natural spawning of the Indian major carps in breeding hapas, artificial or dry fertilization is necessary in the Chinese carps. About 6-8 hours after pituitary injection, the females are stripped and the ova are collected in a circular basin (Fig.1-28). To this milt is added by stripping the males immediately. The stripped ova and milt are mixed gently using a quill to facilitate fertilization. This is called dry fertilization.

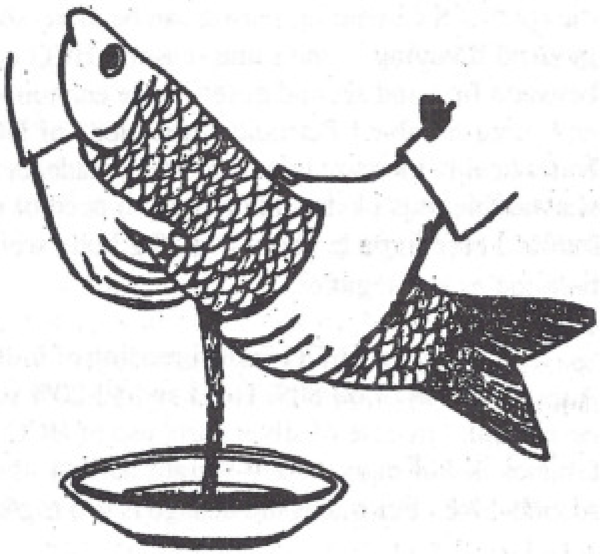

Fig. 1-28. *Spawning through stripping*

For induced breeding 2 year-old silver carp breeders are selected. In the case of grass carp 2 year-old males and 3 year-old females are selected.

The recommended dosages for the grass carp males are 1 mg/kg body weight for first dose and 3 mg/kg body weight for second dose. Females are given 3 mg and 6 mg/kg body weight for first and second doses respectively.

The silver carp males are given only a single dose at the rate of 3-4 mg/kg body weight, while the females require 2 doses at the rate of 3 mg and 6 mg/kg body weight respectively. The fecundity is high, about 70,000 eggs /kg body weight. The eggs are light blue with yellow or golden brown tinge and are demersal. The incubation period is about 20 hours at a temperature range of 25 – 28^{0}C. The hatchlings are slightly larger than those of the major carps.

III. INDUCED BREEDING IN COMMON CARP

The common carp *Cyprinus carpio* breed throughout the year. They attain sexual maturity early in life. They can be induced to breed about 5 time a year. The males are identified by the roughness of the pectoral fin and the presence of tubercles on the sides of the head during the breeding season. The methods of induced breeding are similar to those of the Indian major carps. The common carps can be induced to breed either in hapas or in cement cisterns. A dosage of 2 – 3 mg/kg body weight is recommended. The eggs of the common carp are adhesive. Therefore submerged aquatic weeds like *Hydrilla, Chara,* and *Ceratophyllum*, or tufts of nylon fibres are placed in the breeding hapas to which the eggs are attached. The fecundity of the common carp is about 1,20,000 eggs/kg body weight. The incubation period is about 48 hours.

1.5.5. SUMMARY

1. Fish seed is the critical input for successful culture operations. Indian major carps and Chinese carps grow rapidly and attain sexual maturity in ponds but they do not breed in confined waters like ponds. They breed naturally in flooded rivers, certain reservoirs and artificially constructed bundh-type tanks during monsoon. The seed collected from riverine sources is generally a mixed lot containing both desirable and undesirable varieties and found not suitable for profitable fish culture. With the development of fish culture, fish seed production by artificial methods has also been developed for producing pure quality seed in required quantities under controlled conditions mainly by means of bundh breeding, and induced breeding by hypophysation technique.

2. Bundhs are the semi-confined rain-fed seasonal or perennial water bodies with proper inlet and outlet where fluviatile conditions are simulated during the spawning season. Bundhs are of two types, *viz.*, perennial or wet bundhs and seasonal or dry bundhs. Bundh breeding popular in West Bengal, Madhya Pradesh and Bihar. Bundhs provide large shallow marginal areas which serve as breeding grounds for the fish.

3. Wet bundh is a perennial pond located on the slope of a vast catchment area. During summer, only the deeper portion of the pond retains water containing major carp breeders. After a heavy rain, the bundh gets submerged with water and the fish starts spawning in such a stimulated natural conditions in the shallow areas of the bundh. The wet bundhs are comparatively bigger than the dry bundhs.

4. A dry bundh is a seasonal water body which impounds fresh rain water only during monsoon season. When the bundh gets flooded, selected breeders are released into the bundhs for spawning. Dry bundhs yield pure seed of selected species on a large scale.

5. The topography of the land has a great role to play in the location and distribution of the dry bundhs. In general, a watershed with more than 15 ha of hard land for every hectare of bundhs is considered essential. A spill way and sluice are essential for a bundh to regulate the water level and prevent escaping the fish from the bundh.

6. The most modern bundhs are masonry structures with a sluice gate in the deepest portion of the bundh and one or two waste weirs for overflow of excess water. Apart from the bundh itself, a dry bundh unit consists of a few stocking ponds for breeders, a set of cement hatcheries and an observation post, which could serve as an observation tower-cum-store-cum-shelter.

7. Breeding in wet and dry bundhs commence after continuous rains. Generally Indian major carps and Chinese carps are used to breed in bundhs. In dry bundhs as soon as the water accumulates, a selected number of ripe females and males of major carps in the ratio of 1:2 in 1:1 by weight are introduced on rainy days for spawning. In modern techniques, few pairs of females and males of the total brood stock introduced into a dry bundh for spawning are being hypophysed. It results in the spawning of entire brood stock. The structure of the bundh unit has also undergone some change with the construction of a reservoir at a higher elevation and a series of small bundhs below the reservoir. This enables the bundhs to be filled with water from reservoir at any time during breeding operations without waiting for rain. Catla breeds in a relatively deeper water (>1m) than rohu and mrigal. Grass carp and silver carp have also reported to breed naturally in dry bundhs without stripping.

8. Spawning in bundhs is influenced by a number of factors such as heavy monsoon flood and inundated shallow spawning grounds, low temperature and cloudy days accompanied by thunder storm and rain.

9. After spawning, the eggs are collected from the bundhs with a gamcha type of net and released into earthen hatching pits or hatching hapas or cement hatcheries for hatching. The spawn survival rate is reported to be high in cement hatcheries (97%) when compared to hatching hapas (32 – 35%) and earthen hatching pits (10-15%).

10. Induced breeding of fish by hypophysation technique was first employed by the Brazilians and then by Russians. India was the third country to use this technique successfully in Indian major carps in 1957 and Chinese carps in 1962.

11. Fish pituitary is a small, round and white coloured gland located on the ventral side of the brain. It secretes gonadotropins such as FSH and LH which play an important role in reproduction and spawning of fish.

12. The glands are collected from mature fish during their spawning season either from fresh fish or from those preserved in ice. There is no difference between the pituitary of male and female donor fish.

13. The collected glands can be used immediately or preserved in absolute alcohol. The alcohol should be changed several times to effect dehydration and defattening of the glands. They may also be preserved by freezing or dried in acetone.

14. Pituitary extracts are prepared either in distilled water or in 0.3% saline solution. The pituitary glands (each 5-10 mg) are macerated in a homogenizer with a small quantity of saline or distilled water. Then it is diluted in the same medium to attain a concentration of 1-4 mg of gland / 0.1 ml of the extract i.e. to render the total solute at the rate of 0.2 ml per kg weight of breeders. This

preparation is centrifuged and the supernatant extract is taken for injection. The extract can also be prepared in bulk and preserved in glycerine to save the time in the preparation of injection dose every time.

15. The Indian major carps weighing 1.5 to 5 kg are preferred for induced breeding. The males can be easily distinguished from the female during the breeding season by the roughness of the dorsal surface of its pectoral fins compared to smooth surface of the female. Ripe males with milt oozing freely on slight pressure on the abdomen and females with soft bulging rounded abdomen and with reddish vent are selected for breeding purposes.

16. The selected breeders are given the intramuscular injections of pituitary extract at the caudal peduncle or shoulder region near the base of the dorsal fin. The females are given two doses, the first dose of 2 – 3 mg/kg body weight followed by a second dose of 5 – 8 mg/kg body weight, 4 – 6 hours after the first dose. The males are given only a single dose of 2 – 3 mg/kg body weight at the time of second injection to the female.

17. A set of two males and one female injected with pituitary extract are released into a breeding hapa which is fixed to bamboo poles in a pond, channel or river. Instead of breeding hapa, small concrete spawning pond can also be used. Spawning normally takes place after 3 – 6 hours. After spawning the breeders are removed from the hapas.

18. Low temperature, rain water or showers and cool weather influence the spawning of fish.

19. Indian major carps on an average lay about 2-3 lakh eggs/kg body weight. The fertilized eggs are transparent and non-adhesive. They kept undisturbed in the breeding hapa for 8-10 hours during which time they get water hardened and swollen. Then they are transferred to a hatching hapa.

20. A hatching hapa is a double hapa. The larger outer hapa is made of cloth and the smaller inner hapa is made of round meshed mosquito net cloth. The fertilized eggs are released into the inner hapa. The eggs hatchout in 15-18 hours at 26-30°C. The hatchlings enter the outer hapa through the meshes of the inner hapa. The inner hapa along with the left over egg cases and dead eggs is removed. After 3 days, the spawn in the outer hapa are stocked in nursery ponds.

21. For hatching, in addition to hatching hapas, jar hatcheries and Chinese circular hatcheries are also widely used. For large scale commercial production of spawn, chinese circular hatcheries are used.

22. Besides pituitary extract, other hormones like *HCG*, and synthetic formulations like *ovaprim* and *ovatide* have been used for induced breeding purpose. Though ovaprim and ovatide are costly, they are ready-to use products and requires only a single dose. Other substances like LH-RH analogues, steroids, and clomiphene are also used for induced breeding of fishes.

23. In chinese carps like silver carp and grass carp, the methods of induced breeding are similar to those adopted for the Indian major carps. However, the Chinese carps can not breed naturally in breeding hapas and require artificial or dry fertilization. Hence, about 6 – 8 hours after pituitary

injection females and males are stripped to collect the ova and milt respectively in a basin. Then they are mixed gently to facilitate fertilization. The incubation period of eggs is about 20 hours at 25 – 28°C. The hatchlings are slightly larger than those of Indian carps.

24. In common carp also, the methods of induced breeding are similar to those of the Indian carps. The common carp can be induced to breed either in hapas or cement cisterns. As the eggs are adhesive, submerged aquatic weeds should be placed in the breeding hapas to which the eggs are attached. The incubation period is about 48 hours.

1.5.6. GLOSSARY

Breeding season: Part of the year when a fish species is sexually active. Also called spawning season.

Breeding stock / breeders: Groups of mature male and female fishes reared for breeding purpose.

Brood fish: Sexually mature fish, ready to spawn.

Caudal peduncle: The region between end of the anal fin and origin of the caudal fin.

Milt: The white milky fluid oozing from the male fish consisting of sperms.

Sex ratio: The ratio between males and females of a given population.

Spawning ground: Particular area of the body of water where breeding of a fish species takes place.

Submerged vegetation: Aquatic plants growing under water and may or may not be rooted.

Survival rate: Number of fish alive after a specific period of time expressed as percentage of the initial number of hatchlings.

Watershed: Catchment area of a river system.

1.5.7. MODEL QUESTIONS

1. What is meant by bundh breeding? Describe how the bundh is useful in seed production?
2. Write in detail the steps involved in the process of induced breeding of carps through hypophysation.
3. Describe the induce breeding technique with HCG and ovaprim in carps.
4. Write notes on
   a) Dry bundhs
   b) Ovaprim

c) Fish pituitary gland

d) Induced breeding in Chinese carps

e) HCG

f) Hatching hapa

1.5.8. REFERENCE BOOKS

Jhingran, V.G. 1991, *Fish and Fisheries of India,* Hindustan Publishing Corporation, New Delhi, India.

Ravi Shankar, P. 1999. *Fisheries and Aquaculture*, Lahari Publications, Hyderabad, India.

Pandian, T.J. (Ed.) 2001. *Sustainable Indian Fisheries*, National Academy of Agricultural Science, ICAR, New Delhi.

Dr. P. PADMAVATHI

UNIT – II

LESSON - 2.1

DESIGN AND CONSTRUCTION OF A POND FARM

2.1.1. Objectives
2.1.2. Introduction
2.1.3. Site Selection
2.1.4. Design of a Pond Farm
- **A. Layout of farms**
- **B. Size of the farm**
- **C. Division of the farm area**
- **D. Size, depth and shape of ponds**
- **E. Dike design**
- **F. Pond bottom and Harvesting sump**
- **G. Water supply and Drainage system**
  - **a) Inlets and outlets**
  - **i) Pipes ii) Sluice iii) Monk iv) Turn-down pipe**
- **H. Aerators**

2.1.5. Construction of a Pond Farm
- **A. Methods of construction**
- **B. Schedule of construction**
- **C. Sequence of construction**

2.1.6. Summary
2.1.7. Model Questions
2.1.8. Reference Books

2.1.1. OBJECTIVES

The purpose of this lesson is to

* discuss the important considerations for the selection of site for construction of ponds and

* describe in detail the various steps while designing the farm and construction of ponds.

2.1.2. INTRODUCTION

The success of any aquaculture system relies on its design and construction. The major designing features can be deliberated on the basis of the site, physiography, source and nature of water supply, organisms to be cultured and techniques of management including feeding and harvesting. Of the different types of aquafarms namely land-based farms (ponds, tanks, hatcheries, raceways, etc.) and open-water farms (cages, racks, rafts, pens, etc.), the pond farms alone are accounting for about 80% of the farm structures. In India, the large scale production of fish/shrimp relies entirely on pond culture. Hence, this lesson is aimed to deal with the design and construction of pond farms.

2.1.3. SITE SELECTION

One of the most important aspects of the planning of aquafarms is the selection of site. Proper site selection is the key to successful aquafarming. While considering a site for an aquafarm, several aspects have to be considered like the type and number of ponds to be constructed, the topography of the area, the water supply, the type of fishes to be reared and the metereorological data relating to the temperature, rainfall, evaporation, humidity, sunshine, and wind speed and its direction. Usually sites which are neither economical nor suitable for agriculture, and reclaimed unutilized swampy areas are selected for the construction of ponds.

The basic criterion for the selection of site is that the soil should not be porous. The soil must have the quality of retaining water for a long time. Soil with **silt** and **clay** is more suitable for it has a greater power of water retention and also contributes to the fertility of the water due to its nutrients. Gravelly and sandy soils have poor water retaining capacity and high rates of seepage. Therefore, they are not suitable for fish ponds. The fertility of the soil is dependent largely on the p^H. The soil of the fish pond should have a p^H between 7 and 9.

Generally, the soil in sites selected for coastal pond farms is alluvial. It is usually porous with varying masses of fine roots of mangroves and other swamp vegetation. The preferred soils are clay, clayey loam, silty clay loam, silt loam and sandy clay loam. Sandy clay loam is best for diking.

The other important criterion for site selection is the availability of adequate water supply during culture period. Thus for assured water supply, sites near streams, valleys, reservoirs, creeks or other water resources of permanent nature should be selected for pond construction. The site should have good quality water suitable for culture and should be free from pollution. The farm site should have transportation and nearby marketing facilities.

Prior to designing and construction, the site should be thoroughly surveyed to determine the topography and land configuration. Topography is a word used to describe the shape of the land – whether it is flat or hilly, upland or low land, etc. Topography affects the cost of construction and draining of water. The most useful topography for fish ponds is that which allows water to fill the ponds and drain them by gravitational pull. Ponds built on a slope can be drained easily. The site should be selected in such a way that the soil available by excavating the pond basin should be sufficient to raise the dikes of it.

In case of coastal pond farms, the most important feature for site selection is the tidal regime, on which the culture is totally dependent. The important data needed are the seasonal variations in salinity of the water and access to freshwater to reduce salinity when required. The elevation of the site in relation to the tidal amplitude at the site is the most important feature. The farm should have a creek to supply water whenever high tide prevails in the sea. The high tides occur during new moon and full moon time. The site should be at a level lower to the creek so that water can easily enter the feeder canal of the farm, otherwise the water has to be pumped in and it becomes an expensive operation. A minimum water depth of 0.7 m in the ponds should be maintained. The ideal tidal amplitude at the site should be around 1.5 m. The pond bottom should be a little above the mean low water neap tide level so that the pond could be drained completely at low tide and could be filled with water at high tide.

An ideal location for a brackish water farm is a tidal mud flat which is uncovered during low tide and which is away from the main flow of the river or creek. It is most essential that the farm site is not affected by flood water during the rainy season.

2.1.4. DESIGN OF POND FARM

The design and layout of the farm depends on the species selected for culture and on the size and shape of the area, which inturn determines the number and size of ponds, and position of canals and drainage system. An aquaculture farm is considered to be properly planned when all the water control structures, canals and dikes are mutually complement to each other.

A. Layout of farms:

To describe the major types of pond layout, the conventional classification of fish pond design into barrage ponds, contour ponds and paddy ponds is still in usage.

The **barrage ponds** are constructed in flat or gently sloping valleys, or abandoned river beds, by putting a low dam at a suitable site, preferably in the narrowest point. The source of water is a stream or a nearby river. A spillway has to be built to avoid flooding of the ponds. Suitable drainage has to be provided to prevent flooding and damage to the pond structures.

Contour ponds are also generally located near a stream, canal, river or reservoir and in a wide valley, the bottom having a slightly sloping contour. The farm is situated on one side of the valley only and the floods pass through the other side. The dikes should be built in such away that they can withstand the flood safely.

Paddy ponds are constructed on relatively flat areas surrounded by a dike. Such sites make it possible to use much better layout designs, including separate water supply and drainage channels, inlets and outlets, harvesting sumps, etc. Most of the sites selected for carp, tilapia and catfish culture in freshwater, and fin-fish and shrimp culture in brackishwater or salt water in coastal areas are suitable for this type of ponds.

B. Size of the Farm:

Generally the size of the farm varies from 2 to 200 hectares. The size of a farm has to be determined on the basis of a number of factors. They include the extent of land available, quantity of water, technology to be followed (e.g. extensive, semi-intensive and intensive farms), production and income required to make the enterprise economically viable, and access to markets, manpower and equipment.

C. Division of the farm area:

A farm is divided into different types of ponds namely nursery, rearing and production or stocking or grow-out ponds (Fig. 2-1). The number and size of these ponds depend upon the water source, variety and size of fish to be cultured and type of management. Some aquafarms are also equipped with a hatchery. In farms incorporating hatchery operations, there is a need for brood-stock ponds and spawning ponds. In case of a fish seed farm, only nursery and rearing ponds may be constructed, with a minimal area for stocking ponds for stocking the breeders (Fig. 2-2). In case of a fish production farm, more stocking ponds will be constructed to produce table-size fish after stocking fingerlings. In temperate and cold climates, transitional rearing ponds for juveniles, and wintering ponds or indoor wintering facilities may be needed.

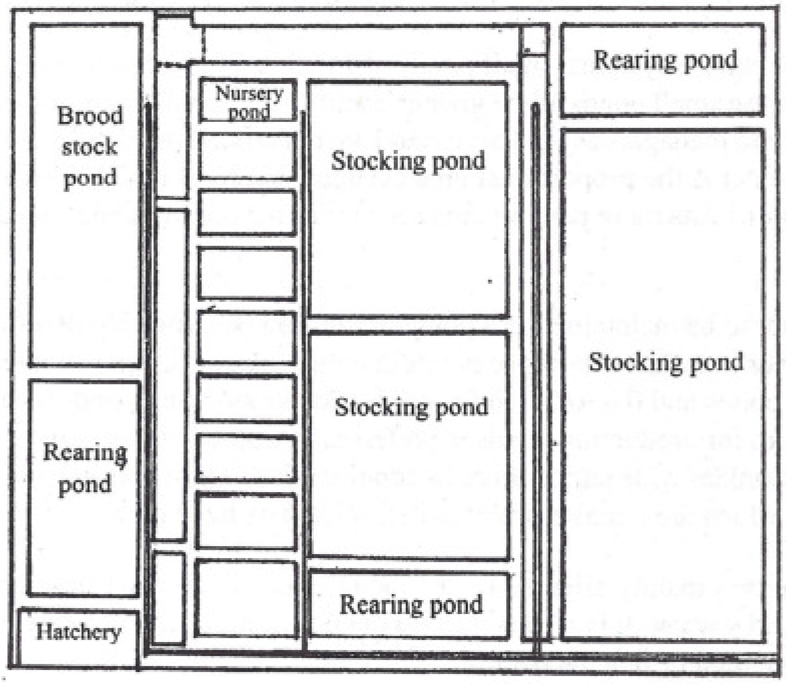

Fig. 2.1. A ten hectare model fish farm

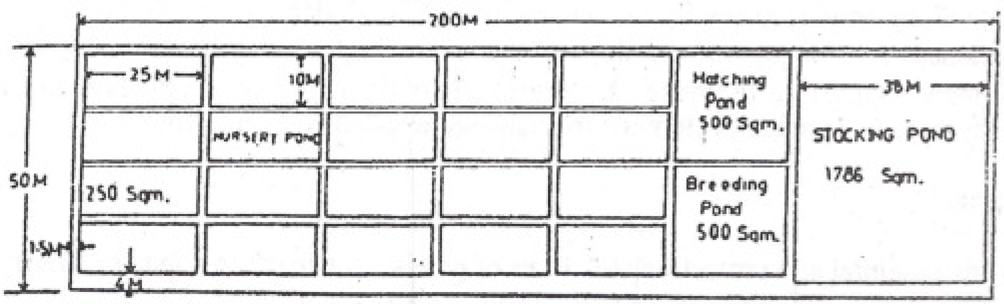

Fig. 2.2. Layout of one hectare model fish seed farm

The different types of ponds may serve different functions in different seasons. For example, spawning ponds can often be used as nursery ponds or production ponds after suitable preparation. Properly designed rearing ponds after the season, can be used as production ponds. However, for a complete aquafarm, all types of ponds are required. The seed requirement and the production target of the farm, based on markets and technology, will decide the area to be assigned for nursery, rearing and production ponds. In general, the production ponds constitute about 70% of the farm area.

D. Size, Depth and Shape of the Ponds:

The size of ponds vary according to the intensity of culture operation. The size of a pond should be optimum for easy operation and management of the farm. Generally a size of 0.05 to 2.00 ha for nursery ponds, and 0.25 to 10 ha for production or stocking ponds has been suggested. Spawning ponds are smaller, ranging from 0.01 to 0.05 ha and holding or market ponds from 0.1 to 1.0 ha.

In semi-intensive culture systems, small ponds of 1 to 5 ha are preferred as against 3 to 10 ha in extensive system, because small ponds allow greater control. The small ponds have the advantages of quick fill or drain, easy to manage, easy to harvest and are not eroded much by wind. However, the smaller the ponds the greater is the proportional area occupied by dikes and drainage ditches. Also, the small pond construction costs more per unit area because of the cost of additional dikes and water supply structures.

The depth of water to be maintained in a pond depends on the climatic conditions and culture practices. The depth varies in different types of ponds in culture systems. An average water depth of 0.4 to 1.5 m for nursery ponds and 0.8 to 3.0 m for production or stocking ponds have been noticed. An average depth of 1.5 m for production ponds is preferred in tropical and subtropical ponds. This water depth not only minimizes wide temperature fluctuations but also assists in reducing the growth of rooted aquatic weeds which are a major problem in tropical fertilized ponds.

The shape of ponds is mainly affected by the factors like i) the ratio between the length of dikes and the area covered by water; this affects the cost of construction, ii) the topography of the area and iii) the anticipated method of fish harvesting.

In a square pond where the ratio of water area to the length of dike is highest, the cost of construction is lowest. If ponds are small and fish harvesting is to be carried out by draining, square ponds are recommended. However, rectangular ponds are preferable to square or other shaped ponds where the width of the pond is generally more than 40 m. This is mainly to facilitate easy harvesting with seins of manageable lengths. If the slope of the area is high, it may be necessary to construct rectangular ponds to enable easy drainage. Also the length of drainage and feeder canals required will be less. Hence, there is a greater preference for rectangular ponds in aquafarms.

E. Dike Design:

Dikes are essential and protecting structures of ponds. Since the life span of a farm depends mostly on the dike system, the dikes should be carefully designed.

i) **Types:**

Dikes are of three types depending on their position and width in the farm. They are: 1) Main or peripheral dikes 2) Secondary dikes and 3) Tertiary or partition dikes (Fig. 2-3).

Main or peripheral dikes: These are enclosing the entire farm area and render overall protection to the stock and related structures. These are wide enough, usually about 6 m, to allow the safe passage of heavy vehicles and equipment. The main dike is of considerable height, sufficiently higher than the highest water level including flood level.

Secondary dikes: These are usually about 4 m wide, allowing the passage of small vehicles such as tractors for hauling the seine net. Depending on the farm design, these are holding water only on inner side or on both the sides when dividing two ponds.

Tertiary or partition dikes: These divide two adjacent ponds and are narrower (1-2 m) and lower in height. The height of this dike depends on pond depth but it should be about 0.5 m higher than the anticipated water level.

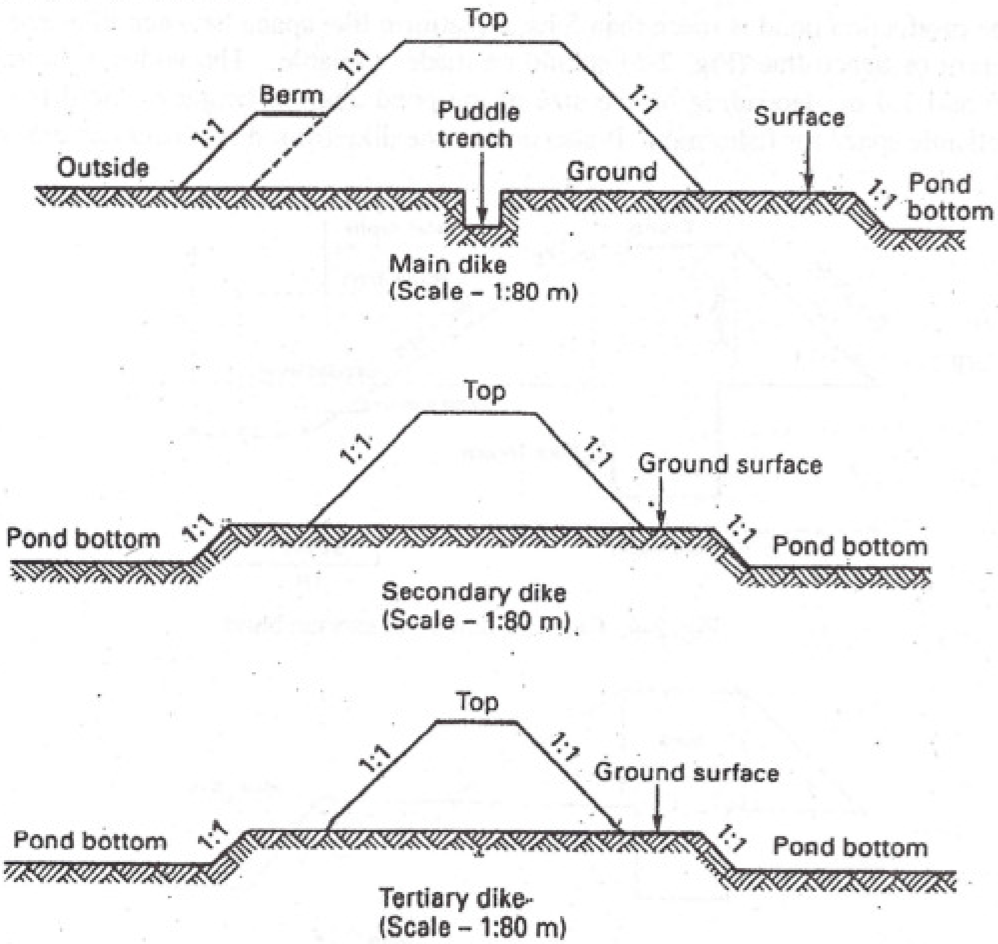

Fig. 2.3. Cross sections of some typical types of dikes.

ii) Slope:

The life span and strength of any dike depend not only on the quality of soil but also on its slope and crown width or crest. Dikes in clay soil have deeper slope than the sandy clay or sandy loam soils. If the height of the dike is 1 m and basal width of its one side is 1.5 m, then the slope is said to be 1:1.5 (Fig. 2-4 and Fig. 2-5). The inside slope (wet slope) of the dike has to withstand the erosion caused by wave action and should be more gradual than the outside slope (dry slope). For ordinary earthen ponds of less than 0.5 ha, the inside slope (wet slope) may be 1:1.5 and the outside slope (dry slope) 1:1. The slope of the dike is based on the quality of soil used for its construction and the required height. If the soil is clay, the wet slope can be 1:2 but for loamy, silty or sandy soils, it should be 1:3. The outer slope of the dike can be steeper and may be 1:1.5 or 1:1. However, the dike that divides the two ponds has two inner slopes (wet slopes) and hence both sides should have a slope of 1:2 or 1:3. The crown width also depends on the height of the dike. However, a minimum of 1 m crown width is invariably needed for any dike. For a dike of a 2 m height, it may be around 2 m.

iii) Berm:

If the production pond is more than 5 ha, a platform like space between dike and water area known as berm or bench-line (Fig. 2-5) should be made available. The width of berm may vary between 0.5 and 1.0 m, depending on the size of the pond and the height of the dike. The berm provides walkable space for fishermen. It also protect the dike from direct contact with water.

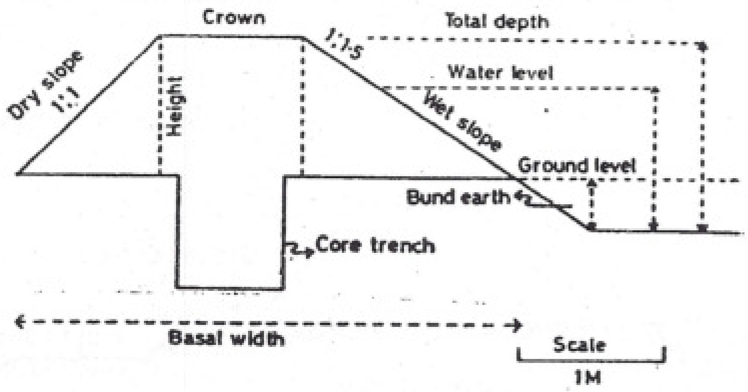

Fig. 2-4. Cross section of an earthen bund

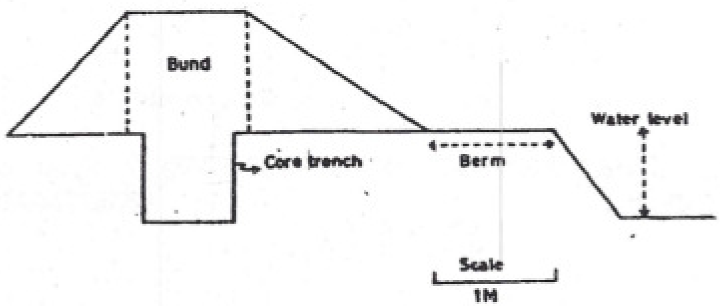

Fig. 2-5 Cross section of an earthen bund showing berm

F. Pond bottom and Harvesting sump:

To facilitate the drainage and harvesting of fish, the pond bottom should have a minimum slope of 0.1 – 0.2% towards the outlet. In inland freshwater ponds, a harvest sump or trench is constructed near the outlet in the deepest part of the pond. The sump may be in the form of a long trench, covering about 20% of the total area or in some other convenient shape, about 50 cm deeper than the surrounding area and with sloping sides to facilitate netting.

Harvesting sumps can also be constructed outside the pond, and a combined sump can be made for a number of ponds. The recommended bottom area for the harvesting sump is around 40 m^2/ha, and the depth 0.6 to 0.1 m. A width of 10-25 m would be convenient for the use of nets. The external harvesting sumps are connected to outlet sluices of the ponds and freshwater has to be introduced into the sump at the time of harvesting. Inorder to prevent rapid siltation, the sump may be constructed 5-10 m away from the dike of the pond. Low levees made of sand stones, gravel, bricks or concrete may be built around the sump to prevent silting.

G. Water supply and Drainage systems:

The water supply and drainage systems have to be designed to convey the required quantities of water in the ponds. For operational safety and efficiency, it is considered essential to have separate feeder and drainage canals, as well as inlets and outlets for each pond. It is generally considered necessary to locate and design the inlets and outlets on opposite sides of a pond, but in some farm designs, the inlet is located near the outlet and the harvesting sump, so as to facilitate the supply of water to the sump when the pond is drained for harvesting.

a. Inlets and outlets:

There are many types of water control structures for use in freshwater and coastal pond farms. The inlets may be anything from a simple pipe to a concrete sluice. The outlet control st.ucture used is the monk or open sluice or turn-down pipe. The type of inlet or outlet used depends mostly on the size of the pond. Probably the most versatile water control structure is the monk which can be used both as outlet and inlet. One major advantage with monk is that by adjusting the control boards or stop logs, the top or bottom layers of water from the pond can be drained efficiently.

i) Pipes: For small ponds, simple pipes are used for water control. The inlet/outlet pipes (15-25 cm diameter) are to be provided with suitable screens to prevent the entry of unwanted fish from outside and the escape of cultivated fish from the pond. The inlet pipe should be arranged in such a way to extend into the pond beyond a foot of the dike to avoid dike erosion. The outlets are invariably installed at the lowest plane of the pond. To stop the flow of water through the inlet and outlet pipes, wooden plugs or gunny cloth can be used as and when needed.

ii) Sluice: Another commonly used water control structure is the open sluice. Sluice gates are commonly used in coastal fish farms in Asia. The sluice is a screened gate used both for inlets and outlets. It is especially useful where the discharges are higher in large ponds (Fig.2-6). Sluice is constructed in the center of the dike wall. It is made of wood or concrete and bricks. It has two or three pairs of grooves for fixing a screen and control boards or a vertical lift gate. By operating the vertical lift gate, the pond can be filled or emptied. The screen helps in preventing the passage of fish.

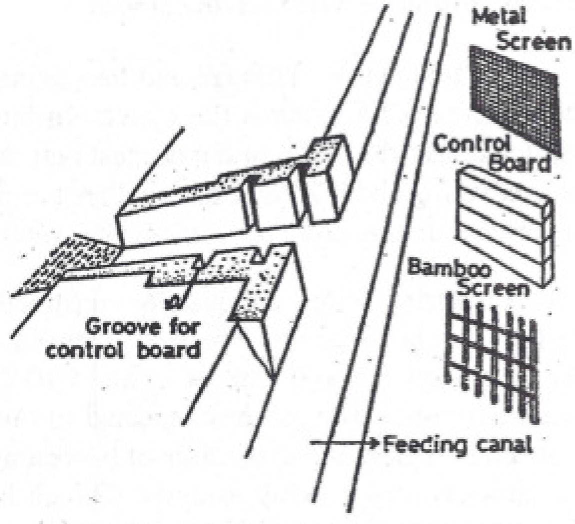

Fig. 2-6. Simple inlet made of concrete and bricks

iii) Monk: It is the most commonly used outlet that regulates the water level in the pond. It is somewhat like the sluice, but not built in the pond wall, the way the sluice is arranged (Fig. 2-7). The monk has two compartments, namely, vertical tower with the three pairs of grooves for housing a screen and control boards, and a horizontal conduit or culvert behind the tower and passing through the dike. It is made up of concrete or brick or a combination of the two. In recent years, monks made of fiberglass, plastic and non-corrosive metal have been used. The height of the tower depends on the highest allowable water level. Three sides of the monk's tower walls are built of concrete or bricks and the fourth side is open towards the pond water. The opening front of the tower need not be more than 40 cm wide for ponds measuring upto 5 ha. The first groove in the tower is for a suitable screen to prevent the escape of fish from the pond. The next two grooves are for control boards. These boards are 2.5 cm thick and 15-20 cm height. The edges of the boards are notched into "halt-lap" to fit together tightly into the groove. The space between the boards can be filled tightly with wet clay, to prevent leakage of water.

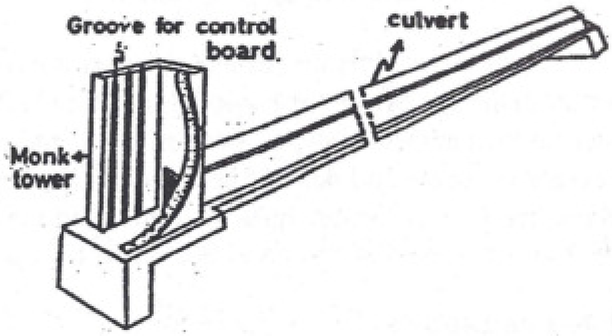

Fig. 2-7. Monk (outlet) with culvert

As the concrete and brick works are heavy structures, strong bases have to be built while constructing monk's tower and culvert. A base of 30-50 cm deep under the tower, 15 cm deep under culvert and 30 cm wide on either side of the structure will have to be constructed with boulders and cement mortar. In case of soft soil, the base may be 60-90 cm deep under the tower, 30 cm under culvert and 50 cm wider on each side of the monk.

iv) Turn-down pipe: In catfish farms in the southern USA, the most popular water regulatory system is the turn-down pipe, located at the lowest point of the base of the dike (Fig. 2-8). It serves as an overflow and drain pipe. The water levels can be adjusted by pivoting the pipe. A screen is provided at the lower end of the pipe to prevent loss of fish. Generally 11 cm pipe will be adequate for small ponds of 1-2 ha, but pipes of 16-32 cm are recommended for 6-8 ha ponds.

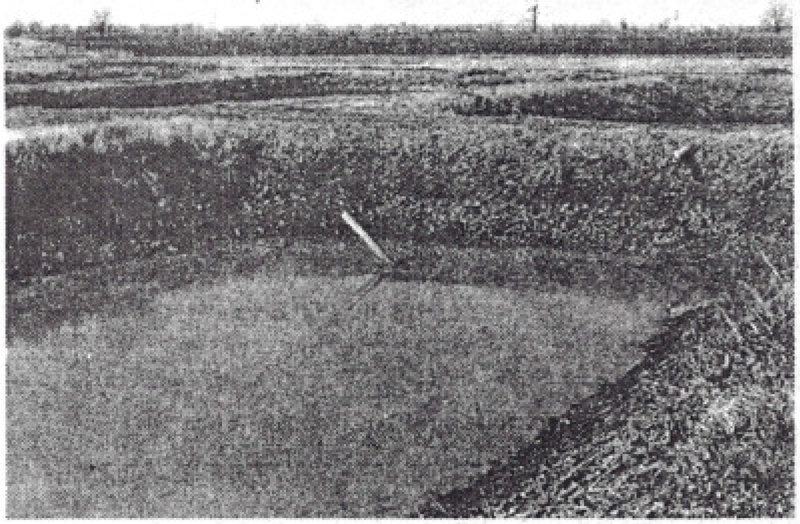

Fig. 2-8. Pnd with turnower standpipe drain. The standpipe can be moved laterally to control water level.

H. AERATORS:

When intensive aquaculture is practiced, some form of aeration system becomes essential to enhance oxygen transfer and the dissolved organic carbon in the water. Gravity aeration is often achieved through weirs and splash boards in ponds and raceways. Simple surface aerators like open impeller or centrifugal pumps and paddle wheels are commonly used to agitate the water and increase the surface area available for oxygen transfer. Depending on the requirement, suitable type of aerator should be designed for the pond.

2.1.5. CONSTRUCTION OF A POND FARM:

A. Methods of construction:

The construction can be carried out either by manual labour or by using mechanical equipment like bulldozers, scrapers, hydraulic power shovels, drag-line excavators, etc. From an economic point of view, mechanical method of construction has many advantages. The construction period can be greatly reduced, the need of more labour force can be minimized, and in many cases, the structures can be constructed more efficiently. However, manual means of construction is essential and proves more efficient for constructing small homestead-type farms and for farms constructed in peaty or swampy tidal lands.

B. Schedule of construction:

The first stage in the construction process involves general planning. For this purpose, a topographical map of scale 1:2000 to 1:2500 is required. This is usually done only after the site has been cleared. General features of the farm, including the types of ponds, dikes, water supply and drainage system, etc., have to be shown on this map. The area reserved for buildings, approach roads and other utilities should also be shown on the map.

The next stage involves the detailed planning of each pond. For this purpose, a topographical work plan of larger scale is required. This will show where and how much earth is to be excavated and where the earth is to be moved. The pond area is divided into 20 x 20 m squares by pegging the ground. The peg line should be parallel to the direction of the longest dike of the pond. The ground level at each peg and the levels of the pegs heads are measured, and the elevations are noted on the work plan of the pond.

Next, the amount of earth required to construct the dikes is calculated from the general plan. Generally, the quantity of earth required per hectare for the construction of dikes of 4 ha pond is estimated to be 2500-4000 m^3. The location and length of the pipeline are designed on the work plan, because all the outlets/drainage pipelines should be constructed before starting construction of the dike.

C. Sequence of construction:

The first step in the construction of a pond farm is marking of the area of the farm. Using the design, the dike lines are pegged along with the contour of the pit from which the required earth is taken out. Sandy and gravelly soil is not suitable for dike construction. Soil with high clay content may also form cracks in the dike leading to seepage. Hence, a mixture of silt, sand and clay in the ratio of 1:3:2 is more suitable for the construction of firm dikes.

The axis of the dike with a base of known length is first pegged and their sides are demarcated. Then the vegetation and organic matter including roots, debris and humus should be removed from the soil used for dike construction, as the rotting of organic matter will weaken the dike. Subsequently, the top fertile soil of 5-10 cm depth is removed and heaped in a nearby area for future use. If the soil of the dike area is of pervious material, then the formation of a core trench or puddle trench is a must (Fig.2-3). The size of core trench depends on the base width and height of the dike. For example, a dike of 3.5 m base width may have a core trench of 0.75 m width and 0.75 m depth. After the area pertaining to the core trench is marked, it is dug and the clay brought from outside is packed in layers and compacted. The core trench is mainly to prevent seepage of water through dike and to strengthen it. It may be avoided if the pond is no deeper than 1 to 1.5 m and soil is clayey and impervious. Then complete all the dikes in the farm with proper arrangements for inlets and aerators wherever necessary.

2.1.6. SUMMARY:

1. Proper design and construction of a farm including the site selection are very important for the success of an aquaproject. Site selection will generally be based on the species to be cultured and the technology to be employed. Generally, the sites not used for agriculture and reclaimed swampy areas are selected for the construction of ponds.

2. Soil with silt and clay is more suitable for pond construction because it has a greater power of water retention. The soil with a p^H between 7 and 9 are considered suitable. Farm site should have a perennial water source, and have transportation and nearby marketing facilities.

3. For coastal pond farms, soils with sandy clay loam is suitable and best for diking. Another important factor for site selection is the tidal regime, on which the culture is totally dependent.

4. While designing a farm, size and shape of the area, the number and size of ponds to be constructed, the position of dikes, canals and drainage system are taken into consideration.

5. Barrage ponds, contour ponds and paddy ponds are the major types of fish ponds. Generally, the size of the farm varies from 2 to 200 ha. A typical farm includes different types of ponds, *viz.*, nursery, rearing, production and breeding ponds. The number and size of these ponds depend upon the farm area, water source, variety and size of fish/shrimp to be cultured and type of management or intensity of culture operation i.e. extensive, semi-intensive or intensive culture systems. In intensive or semi-intensive culture systems, small ponds of 1 to 5 ha are preferred as against 3 to 10 ha in extensive systems because small ponds allow greater control. An average depth of 1.0 to 1.5 m is preferred in ponds.

6. Bunds or dikes are the essential and protecting structures of ponds. They are of three types namely, main, secondary and tertiary dikes. The life span and strength of a dike depend on the soil quality, its slope and crown width. For ordinary earthen ponds having clay soil, the inside slope (wet slope) can be 1:1.5 or 2 but for loamy, silty or sandy soils, it should be 1:3. The outer slope of the dike can be steeper and may be 1:1.5 or 1:1. Berm or bench-line can also be constructed in the bunds for larger ponds.

7. The pond bottom should have a minimum slope of 0.1. to 0.2% towards the outlet to facilitate drainage and harvesting of fish. In inland freshwater ponds, a harvest sump or trench is constructed near the outlet in the deepest part of the pond. Harvesting sump can also be constructed outside the pond.

8. Many types of water control structures are used in freshwater and coastal pond farms. The inlets used may be from a simple pipe to a concrete sluice. The outlet used is the monk or open sluice or turn-down pipe. In intensive culture systems, gravity aerators or simple surface aerators like open impeller, centrifugal pumps and paddle wheels are commonly used for aerating the water.

9. Ponds can be constructed manually by labour force or mechanically by using bulldozers, scrapers, excavators, etc. The first step in the construction process involves the general planning of the farm with a topographical map showing the types of ponds, dikes, water supply and drainage system, buildings, approach roads and other utilities. Next step is the marking of the area and excavation of earth. Further steps involve the construction of outlets/drainage pipelines, formation of core trenches if the soil of the dike area is of pervious nature. Then complete all the dikes in the farm with proper arrangements for inlets and aerators wherever necessary.

2.1.7. MODEL QUESTIONS:

1. Give an account of the design and construction of a freshwater pond farm.

2. Explain the layout, designing and construction details for a 10 ha freshwater fish farm.

3. Write notes on
   a. Criteria for selecting a site for constructing freshwater fish farm
   b. Dike design
   c. Types of inlets and outlets used in pond farms
   d. Design of pond bottom and harvesting sump.

2.1.8. REFERENCE BOOKS:

Pillay, T.V.R. 1990. *Aquaculture Principles and Practices*, Fishing News Books Ltd., Oxford.

Jhingran, V.G. 1991. *Fish and Fisheries of India*. Hindustan Publishing Corporation (India) Delhi.

Stickney, R.R. 1979. *Principles of Warm water Fish Culture*, John Wiley & Sons, New York.

Dr. P. PADMAVATHI

UNIT – II

LESSON - 2.2

MANAGEMENT OF CARP CULTURE PONDS: NURSERY, REARING AND STOCKING PONDS

2.2.1. Objectives
2.2.2. Introduction
2.2.3. Nursery Pond Management
- **A. Pre-stocking management**
  - **i) Dewatering and drying**
  - **ii) Desilting**
  - **iii) Control of predatory and weed fishes**
  - **iv) Control of aquatic weeds**
  - **v) Liming**
  - **vi) Watering**
  - **vii) Fertilization**
  - **viii) Control of algal blooms**
  - **ix) Control of aquatic insects**
  - **x) Water quality**
- **B. Stocking**
- **C. Post-stocking Management**
- **D. Harvesting of fry**

2.2.4. Rearing Pond Management
- **A. Pre-stocking management**
- **B. Stocking**
- **C. Post-stocking management**
- **D. Harvesting of fingerlings**

2.2.5. Stocking Pond or Production Pond Management
- **A. Pre-stocking management**
  - **i) Dewatering and drying**
  - **ii) Liming**
  - **iii) Watering**
  - **iv) Fertilization**
  - **v) Water quality**
- **B. Stocking**
- **C. Post-stocking management**
  - **i) Feeding**
  - **ii) Water quality management**
  - **iii) Growth and health care**
- **D. Harvesting**

2.2.6. Summary
2.2.7. Model Questions
2.2.8. Reference Books

2.2.1 OBJECTIVES

The purpose of this lesson is to

* describe briefly the types of ponds in a carp culture farm and
* describe in detail the pre-stocking, stocking and post-stocking management practices in nursery, rearing and stocking ponds with the scientific management techniques developed to achieve maximum fish production.

2.2.2. INTRODUCTION

Different types of ponds are required for the culture of different life history stages of carps in fish farms. They are nursery, rearing and production or stocking ponds. The number, size and the ratio of these ponds depend upon the farm area, water source, size of fish to be cultured and type of management. According to Alikunhi, under Indian conditions, a 4 ha fish farm should have the following ratios; nursery ponds – 0.2 ha, rearing ponds – 0.8 ha and stocking ponds – 3 ha. A brief description of these types of ponds is as follows.

Nursery ponds: These are the smallest of the fish ponds and usually measure about 0.02 – 0.06 ha in size and 1 m in depth. These are meant for nursing the hatchlings/spawn (5-6 mm) for a period of 15 to 30 days until they become fry (2.5 – 3.0 cm). In practice about 10 million spawn per hectare are stocked in nursery ponds. Since these ponds are used only for a short time, they could be used two or three times in a single breeding season. During the other seasons, the nurseries can also be used as rearing or production ponds. The nursery ponds may be earthen or constructed with brick and cement above ground level in order to reduce the mortality rate of the fry.

Rearing Ponds: These are slightly larger than the nursery ponds and usually measure about 0.08 – 0.1 ha in size and 1.0 to 1.5 m in depth. In rearing ponds, the fry are grown for about 2 to 3 months until they become fingerlings (8 – 12 cm). During off-season, these may be used as production ponds.

Production or Stocking Ponds or Grow-out ponds: These are the largest among other ponds in a farm. The size of these ponds varies from 0.4 to 40 ha or more but the ideal size for efficient management is 2 to 4 ha. The depth of water in these ponds varies from 1.5 to 3 m. In these ponds, the fingerlings and advanced fingerlings or juveniles are reared upto marketable size for about six months to one year. Two types of construction are followed *viz.*, trench method and full digging. Almost 90% of fish ponds are constructed by adopting the trench method. It facilitates easy harvesting of fish. The economic size of the ponds depends on the ecological conditions of the area and the type of fish culture.

Proper management of these ponds is important for successful rearing of spawn, fry, fingerlings and adult fishes.

2.2.3. NURSERY POND MANAGEMENT

Management of nursery ponds is one of the most important aspects for successful fish culture practices. The nursery pond is meant for growing spawn to fry stage. The spawn and fry are extremely delicate and succumb to abrupt changes in water quality and can be easily preyed upon. Hence, these should be reared with utmost care to get a very good survival rate. Small and seasonal nurseries are preferred as they help in effective control of the environmental conditions. The nursery pond management includes pre-stocking, stocking and post spawn stocking management.

A. PRE – STOCKING MANAGEMENT:

i) **Dewatering and drying:** The nursery pond management operations start right from the summer. First water is removed from the ponds and then exposed for sun drying. Drying of ponds in summer helps in the mineralization of soil, removal of organic detritus, and automatic destruction of pathogens, aquatic weeds, and predatory and weed fishes (unwanted fishes).

ii) **Desilting:** The silt with rich humus or excess organic matter at the bottom is removed and this can be used to fill the sides and for strengthening the bunds. This soil has manurial value and helps to increase the productivity of the pond after watering. Minor repairs pertaining to inlet and outlet are to be made during this time.

In deep perennial ponds which can not be drained, special steps are called for to remove predatory and weed fishes, and aquatic weeds.

iii) **Control of predatory and Weed Fishes:** The common predatory fishes are *Channa* spp., *Wallago attu, Heteropneustes fossilis, Clarias batrachus, Anabas testudineus*, etc. These cause heavy mortality of spawn as they feed on spawn. The common weed fishes are *Puntius, Salmostoma, Rasbora, Barilius, Chela, Esomus, Amblypharyngodon*, etc. The weed fishes are not predatory but they compete for food and space with the culture fish. Hence, they must be eradicated from the nursery pond either by netting or by poisoning. The problem of controlling predatory and weed fishes arises only when the nursery ponds are perennial and undrainable

Poisons or fish toxicants derived from plants, chlorinated hydrocarbons and organophosphates are commonly used. Poisons from plant origin such as derris root powder (5 ppm), mahua oil cake (200 ppm) and tea seed cake (75-100 ppm) are commonly used. 1) Derris root powder also effectively control the other predators like frog tadpoles, aquatic insects and their larvae, snails, etc. The active ingrident in this is rotenone. It is a contact poison affecting the respiratory system leading to death. Since its toxic effect lasts for one to two weeks, it should be applied at least 12 days prior to stocking the pond. 2) Mahua oil cake has saponin (4.6%) as chief poisonous component, which enters the blood stream and causes hemolysis of red blood cells, there by leading to death of fish in about five hours. It should be applied a fortnight before stocking. After its lethal effect (i.e. after 10 days) it is useful as manure in the pond.

Chlorinated hydrocarbons such as aldrin (0.2 ppm) dieldrin (0.01 ppm) and endrin (0.001 ppm for insects and 0.01 ppm for fish) and organophosphates such as phosphamidon, nuvan (DDVP) at the rate of 2-20 ppm are used to eradicate the unwanted fishes and other predators. These should be treated atleast a month prior to stocking. However, the use of chlorinated hydrocarbons is banned and they are not available.

iv) **Control of aquatic weeds:** Aquatic weeds affect the fish culture by limiting the space for movement, competing with phytoplankton by absorbing nutrients, causing imbalance in the dissolved oxygen concentration, causing siltation, hampering netting operations and harbouring unwanted fishes, insects and molluscs, which act as vectors for many diseases.

Aquatic weeds of the fish ponds are of the following types. **Algal weeds** (*Spirogyra, Chara* and *Nitella*); **floating weeds** (*Eichhornia, Lemna, Pistia, Azolla* and *Salvinia*); **emergent weeds** (*Nymphaea, Nymphoides, Myriophyllum* and *Typha*); ***submerged weeds*** (*Vallisneria, Hydrilla, Najas, Utricularia* and *Ceratophyllum*) and **marginal weeds** (*Marsilia, Jussiaea, Ipomoea*, etc) (Fig. 2-9).

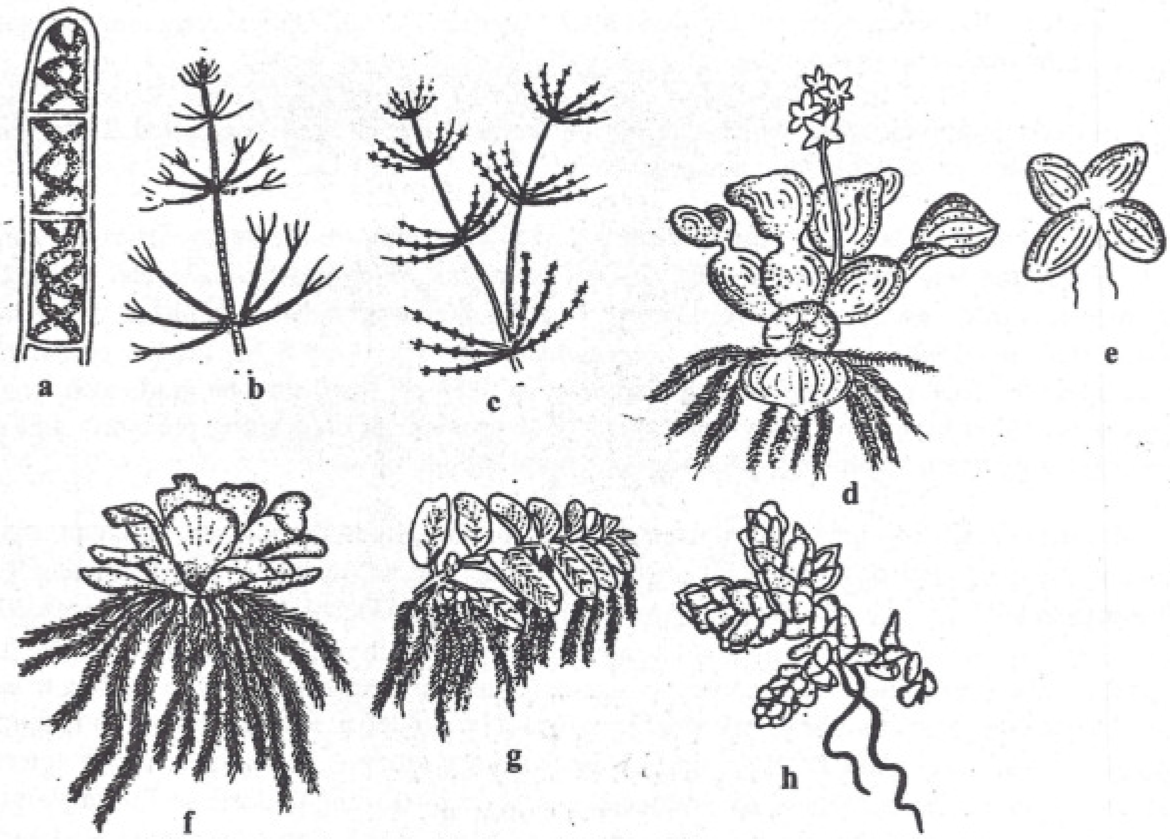

Fig. 2.9. Aquatic weeds. Algal weeds (a-c): a) *Spirogyra* b) *Nitella* c) *Chara*

Floating weeds (d-h) : (d) *Eichhornia* e) *Lemna* f) *Pistia* g) *Salvinia* h) *Azolla*.

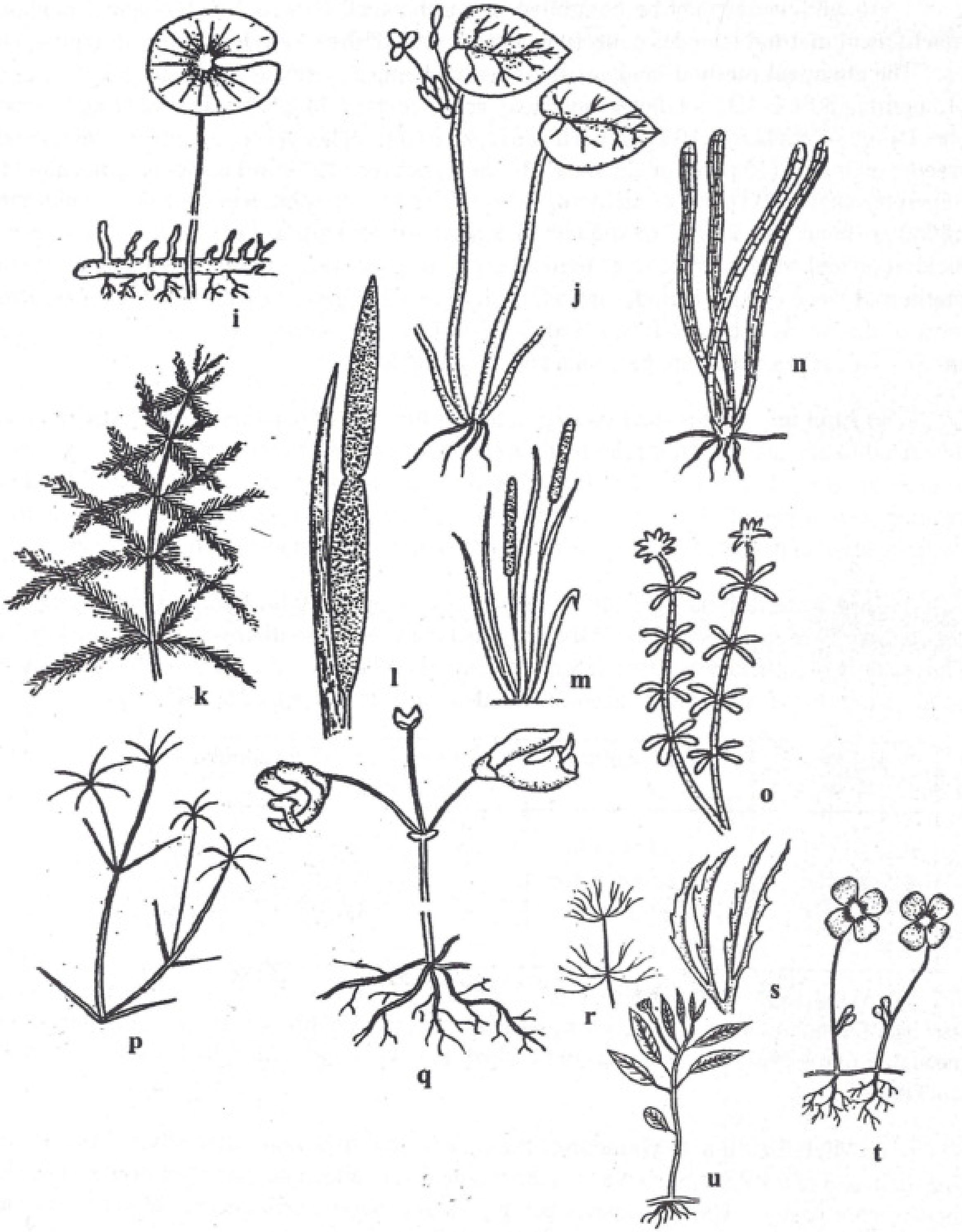

Fig. 2.9. Emergent weeds (i-m) : i) *Nymphaea;* j) *Nymphoides;* k) *Myriophyllum;* l & m) *Typha;* Submerged weeds (n-s) : n) *Vallisneria;* o) *Hydrilla;* p) *Najas;* q) *Utricularia;* r & s) *Ceratophyllum* Marginal weeds (t & u) t) *Marsilia* u) *Jussiaea.*

Aquatic weeds may be controlled by mechanical, chemical or biological methods. The **mechanical method** includes collection and disposal of the weeds by cutting, dragging, ploughing, etc. The **chemical method** involves spraying of chemicals such as simazine (5 kg/ha) or ammonia (15 ppm) or 80% 2-4D (2-4 dichlorophenoxy acetic acid) (5-7 kg/ha) or Diquat (1 kg/ha) for **floating weeds;** dichlorophenyl (10 kg/ha) or fenae (2,3,6 trichlorophenyl acetic acid) (10 k/ha) for **emergent weeds;** ammonia (15 ppm) or simazine (3-5 ppm) or urea (250 ppm) or Sodium arsenite (4 ppm) or Superphosphate (500 ppm) or dichlorophenyl (10 kg/ha) for **submerged weeds**; dichlorophenyl (10 kg/ha) or fenae (10 kg/ha) or diquats (1 kg/ha) for **marginal weeds.** It should be noted that dichlorophenyl and fenae are to be used after draining the water from the fish pond. The **biological method** of weed control includes introduction of fish like grass carp and common carp that feed on most of the weeds except *Salvinia* and *Eichhornia*. The weeds are controlled before stocking of spawn in nurseries which are perennial and undrainable.

v) **Liming:** This is the first step in the fertilization of a nursery pond. After eradicating the unwanted fishes and weeds, if present, lime should be applied in the pond. Liming is most essential to maintain the pH of water. The water should be slightly alkaline because the fish food organisms develop well at pH 7.5-8.5. Application of lime to the pond bottom helps to eradicate the harmful bacteria and fish parasites and also helps to maintain the hygienic condition of water.

Lime materials like agricultural lime ($CaCO_3$), hydrated lime (CaOH) and quick lime (CaO) are commonly used in fish ponds. Of these, CaO is the best and most commonly used in fish ponds. The quantity of lime to be applied depends on the pH of the soil. Lime is applied uniformly on the dry pond bottom in the following concentration atleast a fortnight before fertilization.

pH of soil	Soil condition	Dose of lime to be applied kg/ha
4.0-4.5	Highly acidic	1000
4.5-5.5	Medium acidic	700
5.5-6.5	Slightly acidic	500
6.5-7.5	Near neutral	200

vi) **Watering:** While watering the pond, care should be taken to avoid the entry of exogenous fish into the pond either at egg, young or adult stage. For this, water should be let into the pond through a fine sieve. The pond has to be filled with water upto a depth of one metre a week before stocking.

vii) **Fertilization or Manuring:** Fertilization has to be done after filling the pond with water. The main aim of fertilization of water is the production of adequate quantities of plankton, the natural food of carp spawn. The carp spawn being planktophagous, maintenance of sufficient quantity of plankton in nursery pond before stockig the spawn is a prerequisite.

Fertilizers used in ponds are of two types, viz., organic manures and inorganic fertilizers. The organic manures commonly used in ponds are cowdung/cattledung, poultry manure, pig manure, compost, etc. and inorganic fertilizers are superphosphate, DAP, urea, murate of potash, N:P:K, etc.

Nitrogen, phosphorus, potassium, calcium and magnesium play a significant role in pond fertility along with trace elements like manganese, boron, iron, copper, zinc, cobalt, etc.

The most commonly used manure for nursery ponds is raw cattledung. The application of rawcattle dung at the rate of 10 to 15 tonnes/ha a week before stocking the spawn and 5 t/ha 7 days after stocking the spawn maintains a good amount of zooplankton in the pond.

Overdoses of organic manure may have adverse effects on fish fry, particularly in causing bacterial and fungal diseases and oxygen depletion, leading to mass mortalities. A mixture of 5 t/ha of raw cattledung, 250 kg/ha of single superphosphate or 80-100 kg/ha of DAP and 250 kg/ha of groundnut oil cake has been found to yield adequate plankton in about 3 days. This mixture is soaked and mixed thoroughly with water to form a thick paste and spread on the surface of the water five days before stocking the spawn.

If sufficient plankton is produced with organic manures, addition of chemical fertilizers is normally avoided, since it may lead to the development of algal blooms followed by oxygen depletion. However, the application of organic manure may be avoided if the pond has already been treated with mahua oil cake as it serves not only as a piscicide but also as a source of organic manure.

viii) **Control of algal blooms:** Some times in highly fertilized nursery ponds, algal blooms are formed. Algal blooms are invariably caused by unicellular and filamentous algae which impart green, reddish-brown and bluish-green colouration to the water. Algal blooms are caused by *Euglena, Chlamydomonas, Volvox, Peridinium* and blue-green algae like *Microcystis, Anabaena, Oscillatoria, Arthrospira, Spirulina,* etc. (Fig. 2-10).

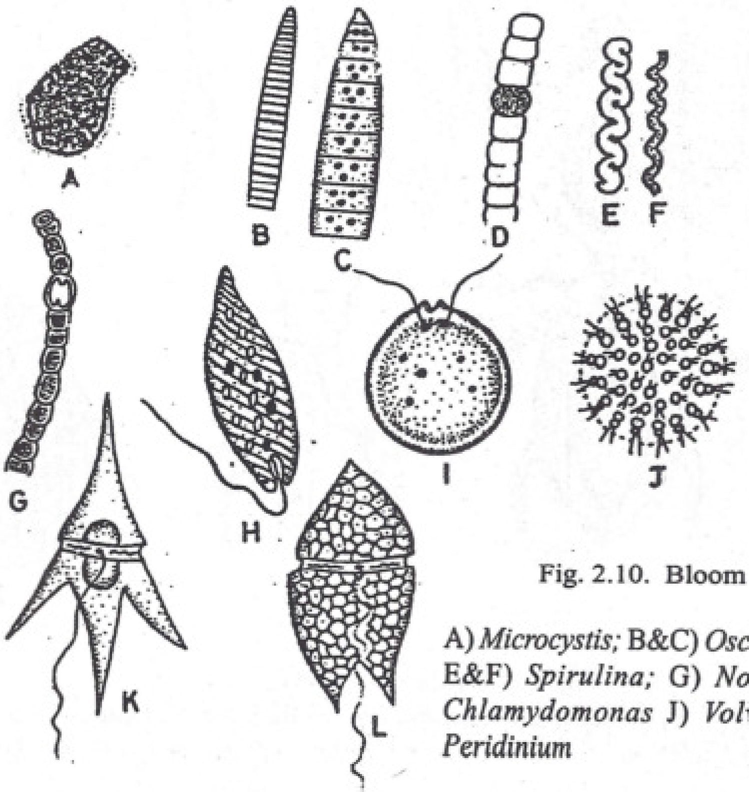

Fig. 2.10. Bloom forming algae

A) *Microcystis;* B&C) *Oscillatoria* D) *Anabaena,* E&F) *Spirulina;* G) *Nostoc* H) *Euglena,* I) *Chlamydomonas* J) *Volvox* K) *Ceratium* L) *Peridinium*

These can be controlled by the application of 1 ppm copper sulphate or 0.5 ppm simazine or by covering the surface of the pond with the duck weed *Lemna*. *Lemna* covering the surface of the water and prevents the growth of algae. With these methods the blooms are controlled within 3-4 days. The duck weeds should be removed from the pond with a cloth net 1 or 2 days before stocking the spawn.

ix) **Control of aquatic insects:** After watering and fertilization, predatory aquatic insects may sometimes develop enormously. Predatory aquatic insects belonging to the orders Hemiptera and Coleoptera cause heavy damage to spawn. Water strider (*Hydrometra)*; back swimmers (*Notonecta* and *Anisops*); water scorpions (*Laccotrephes*) and stick insect (*Ranatra*); giant water bugs (*Diplonychus* and *Lethoceros)*; diving beetles (*Cybister, Hydaticus, Eretes, Laccophilus);* whirligig

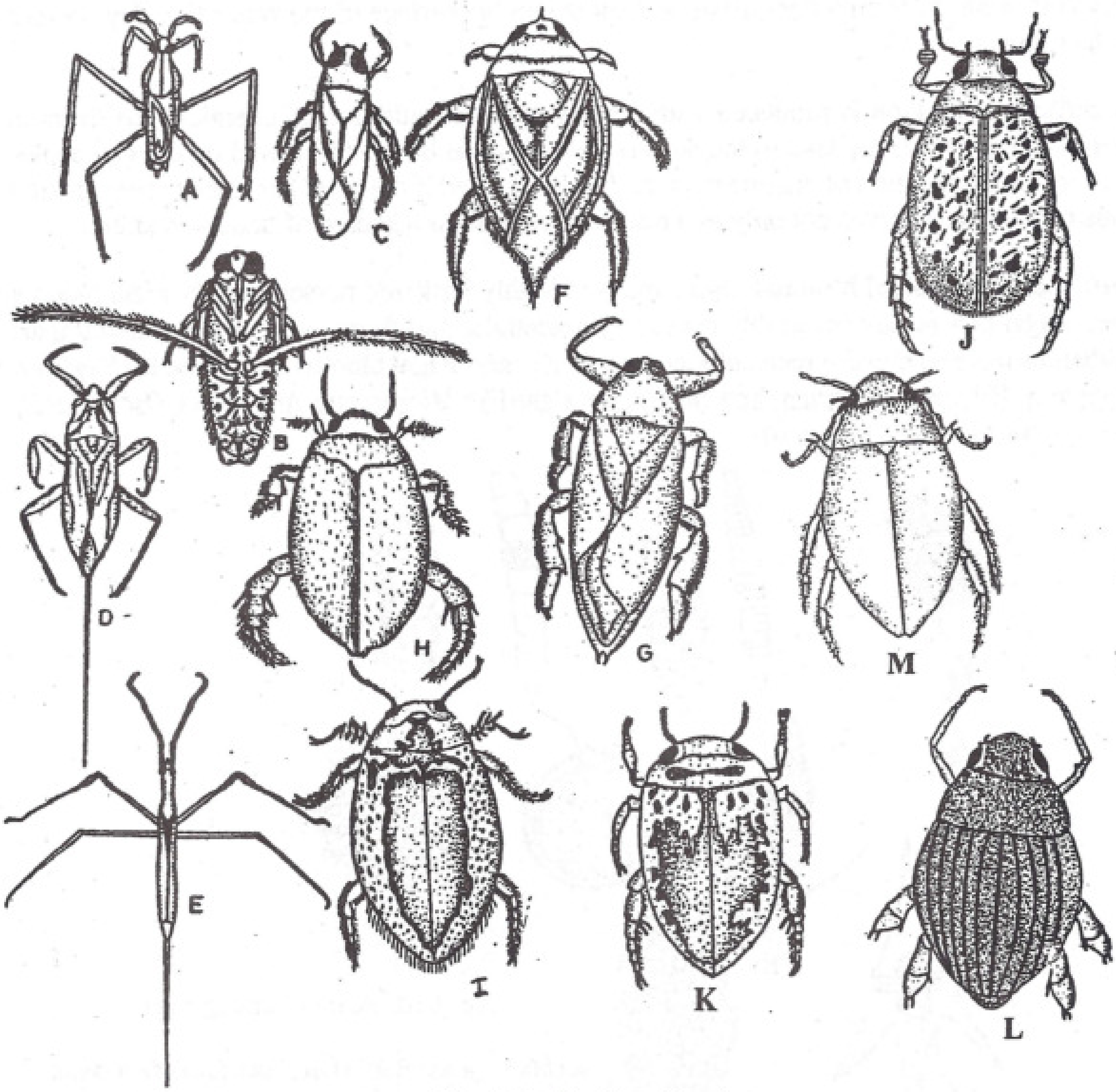

Fig. 2.11. Predatory insects.
A) *Hydrometra;* B) *Notonecta;* C) *Anisops;* D) *Laccotrephes;* E) *Ranatra;* F) *Diplonychus;* G) *Lithocerus;* H) *Cybister;* I) *Hydaticus;* J) *Eretes* K) *Laccophilus L) Dineutes* M) *Hydrophilus.*

beetle (*Dineutes*); nymphs of dragon flies and damsel flies are commonly encountered in fish ponds (Fig. 2-11). They are highly detrimental to fish spawn and fry. They not only prey on fish seed but also compete for food. Hence, the insects should be eradicated prior to stocking of spawn to ensure maximum survival.

Repeated drag netting in the pond or spraying of oil emulsion on the surface of water a day prior to spawn stocking in nursery pond is most effective in controlling the insects. The oil emulsion with 60 kg of oil and 20 kg soap are sufficient to treat one hectare of water. The soap is first dissolved in water and it is added to the oil and stirred thoroughly. It is then spread on the surface of water during still weather condition so that a thin film is formed on the water.

The film formed due to the emulsion, blocks the respiratory organs of most of the aquatic insects which normally come to the surface to breathe the atmospheric air. All the insects die of suffocation within five hours of application and the effect of emulsion lasts for 10-15 hours. If insects are further noticed, they can be eradicated by using dieldrin (0.5 ppm), benzene hexachloride (0.1 ppm), etc.

The prepared nursery pond is ready to receive the spawn. However, for higher survival and growth, optimal physico-cemical parameters of water and plankton should be maintained.

x) **Water quality:** Brown colour of water indicates rich zooplankton growth and green or blue colour indicates dominance of algae in the plankton. Some of the chemical parameters of the water in the following range are considered to be optimal for survival and growth of spawn.

Dissolved oxygen	-	5-10ppm
pH	-	7.5-8.5
Carbon dioxide	-	<15 ppm
Ammonia	-	<0.5 ppm
Phosphate	-	1.0-20 ppm
Nitrate	-	1 ppm

It is evident that 4 to 5 ml of plankton per 100 liters of pond water is essential for satisfactory spawn stocking. Rotifers, cladocerans, green algae and diatoms form the preferential food of major carp spawn.

B) **Stocking:** Nursery ponds generally stocked at the rate of 5-6 million spawn/ha. Recently, in some farms, good survival (80%) and growth has been observed with the stocking density of 10 million/ha for 11 days of rearing. The stocking should be done either in the early morning or late evening after gradual acclimatization of the spawn to the pond water.

C) Post-stocking Management:

Feeding: Soon after stocking, the spawn start feeding voraciously on the plankton. As a consequence plankton gets depleted in 2 or 3 days of stocking. Survival and growth of spawn are influenced mostly by the quantity and quality of food available in the pond. Hence, artificial feeding is necessary along with plankton from the next day after stocking. The major carp spawn of 5-6 mm length weighs about 1.4 mg. Usually the spawn in nursery ponds are fed with rice bran and finely powdered groundnut oil cake in 1:1 ratio by weight at the rate of 2 to 4 times the body weight of spawn stocked. The feed is broadcast in the pond. The feeding schedule is as follows.

2 – 5 days - double the initial body weight of the spawn stocked
6 – 10 days - thrice the initial body weight of spawn stocked
11 – 15 days - four times the initial body weight of the spawn stocked

For better utilization, half of the feed is given during the morning hours and half during the evening hours every day. Birds like herons and cranes are controlled by shooting, scaring or surface netting of the pond.

D) **Harvesting of fry:** In 15 days of nursery rearing, the spawn grows to a size of 20-25 mm fry. At this stage, the fry could be harvested and transferred to *rearing ponds*. Supplementary feeding should be stopped a day before harvesting. The harvesting should be carried out in the early morning or in the late evening to minimize mortality of the fry. Using 1/16" mesh drag net, pond is harvested by repeated netting. The survival rate would be 60-80%.

Since the period of nursing of spawn is only 15 days, 3 to 4 crops of fry can be raised in a season of 3 months from the same nursery pond. In such cases liming and manuring of the nursery pond should be done every time at the rate of 150 kg/ha and 5000 kg/ha respectively in order to compensate the deficiencies of nutrients caused by the previous stock of fry.

2.2.4. REARING POND MANAGEMENT:

Most of the management practices of the rearing pond are similar to that of a nursery pond. The rearing pond differs from the nursery pond mainly in its stocking with fry of different species. The rearing pond should be located near the nursery and stocking ponds. This would help easy transportation of fry. Like nursery, the rearing pond is also a seasonal pond, where the fry are grown to fingerlings in about 3 months.

A) **Pre-Stocking Management:** Preparation of the pond including dewatering and drying, control of unwanted fishes and aquatic weeds is similar to that of the nursery pond.

Fertilization: As in the case of nursery pond, the rearing pond is also first limed and fertilized with organic manure (cowdung) at the rate of 10-15 t/ha. The plankton developed by this organic manure may diminish within 2 or 3 days after stocking the fry, due to their feeding activity. Hence, chemical fertilizers such as urea and superphosphate should be applied at the rate of 40-80 kg/ha once in 15 to 20 days to boost plankton production.

B) **Stocking:** The stocking density of fry may be between 2-3 lakhs/ha. The fry of different species can be stocked together usually in the following combinations:

catla, rohu and mrigal,	-	1:2:2
catla, rohu, mrigal and common carp	-	3:4:1:2

catla, rohu, mrigal, silver carp, grass carp
and common carp - 2:4:4:4:3:3

C) Post –Stocking Management:

Feeding: After few days of stocking in the rearing pond, when the plankton goes down, addition of supplementary feed is essential to enhance the growth of young fish. Usually a mixture of groundnut oil cake powder and rice bran (1:1) is broadcasted in the pond or soaked in water for sometime and made into small balls, which are placed in bamboo baskets or earthen bowls and kept in shallow regions of the pond at 3 or 4 places for the purpose of feeding.

To minimize the period of rearing and to enhance the growth rate, protein-rich items such as silkworm pupae, soyabeen, trashfish and prawn wastes may also be added to the feed. An artificial feed containing 40% protein is found more suitable for the growth of carps. In addition, growth promoting nutrients like vitamin-B complex, yeast, cobalt chloride, etc. may also be included in the feed to enhance the growth of the fish. To safeguard the fish from infections and diseases, antibiotics like terramycin may be sprayed on the feed at the rate of 100 mg/kg feed.

The supplementary feed is given initially at the rate of 1% of the total body weight of fish and subsequently increased to 2-4% depending on the utilization. However, manuring and supplementary feeding should be stopped when there are algal blooms.

D) **Harvesting of fingerlings:** The method of harvesting is similar to that of nursery pond. Unlike the nursery pond, the rearing pond is used for growing fry only once in a season. Hence, during the rest of the year the rearing pond can be used as production pond for growing fish of marketable size.

2.2.5. PRODUCTION POND OR STOCKING POND MANAGEMENT:

In production pond, fingerlings are stocked and reared for about 9-12 months or until they attain marketable size. The management practices in rearing and production ponds are almost similar. To get maximum yield of fish, utmost care should be taken at all steps of management. The principles in the rational management of production ponds are: the culture of fast growing species; increasing the carrying capacity of ponds by fertilization and supplementary feeding; optimal utilization of ecological niches in the pond by stocking manipulation, maintenance of water quality, and fish health monitoring.

A. Pre-stocking management:

Pond Preparation:

i) **Dewatering and drying:** If the pond is an old one from which the fish have been harvested, it should be completely dewatered and ploughed. Then the pond is exposed to sunlight for a week or two, so that mineralization of the accumulated metabolites and organic matter of the previous culture takes place and increase the soil fertility. A further advantage is the total eradication of weeds, pests and predatory and weed fishes.

In case of undrainable ponds or when drying is not possible, the aquatic weeds, predatory and weed fishes and other predators, if any, should be controlled by the methods as discussed earlier in 'Nursery pond Management' of this lesson.

ii) **Liming:** Lime is frequently applied in aquaculture practices to improve water quality. It is both prophylactic and therapeutic. The lime should be evenly spread over the dry pond bottom to bring the soil pH to alkaline condition, which is ideal for fish production. The amount of lime to be applied depends upon the soil pH, as given in 'Nursery Pond Management'. For deriving the full benefit from the treatment, it is desirable to leave the pond dry for atleast 10 days after application. Even after stocking the fish, it is better to add lime based on water pH at fortnight or monthly intervals throughout the culture period.

iii) **Watering:** The water should be let in slowly to fill the pond. Screens should be used at inlets so that the unwanted fishes and other organisms will not enter into the pond. The quality of water in the pond should be checked before the fish is released into it.

iv) **Fertilization:** One of the major factors determining the survival and growth of fish is the availability of proper food in adequate quantities. Plankton form the natural and healthy food for carps. In order to develop the fish food organisms, pond should be fertilized by both organic and inorganic (chemical) fertilizers.

Organic manure is of three types, viz. a) *liquid manure* (urine and sewage rich in nitrogenous matter), b) *farm manure* (cow/cattle dung, pig dung and poultry manure; and c) *plant manure* (green manure, compost, mahua oil cake, etc.). Organic manures are regarded as 'complete fertilizers' because of the presence of all the three major nutrients N,P and K. The manure also consists of organic carbon, trace elements, vitamins and microorganisms. These are slow acting but long lasting. Proper care should be taken while using the manures. Overdoses cause oxygen depletion in pond water which may lead to heavy mortality of fish by asphyxiation.

Generally cowdung is applied at the rate of 20-30 tonnes/ha. However, poultry manure at the rate of 5-10 tonnes/ha is known to enhance zooplankton production. The first instalment should be one-fifth of the total quantity of manure, about 10 days before stocking with fingerlings and the rest in equal instalments at fortnight or monthly intervals during the culture period. If mahua oil cake has already been used, the first instalment of organic manure may be reduced by 25%.

The application of **chemical fertilizers** depends on the nature of soil i.e. its phosphorus and nitrogen contents. The soil may be of three types depending on its phosphorus and nitrogen contents.

Nature of soil	P_2O_5 (mg/100g)	N (mg/100g)	Organic carbon (%)
Highly fertile	6-12	50-75	>2
Medium fertile	3-6	25-50	1.2
Less fertilie	<3	<25	<1

Generally hard water needs more nitrates and soft water more phosphates. For a production pond of medium fertile soil, urea (200 kg/ha/yr), single superphosphate (250 kg/ha/yr) or diammonium phosphate (100 kg/ha/yr) and murate of potash (40 kg/ha/yr) should be applied in equal instalments at fortnight or monthly intervals during the culture period. The dosages may vary depending on the intensity of culture. Micronutrient fertilizers are also used when necessary. However, application of fertilizers should be suspended when algal blooms appear.

v) **Water Quality:** Water is the primary requisite to support aquatic life. Water quality is influenced by physical, chemical and biological factors. The important parameters like temperature, turbidity, dissolved oxygen, pH, hardness, alkalinity, chlorides, ammonia, nitrates, and phosphates should be analyzed before stocking the fish and maintained at optimum levels for their survival and good growth. The maintenance of sufficient quantity of plankton is also most important. It should be 2 to 3 ml/100 L of pond water. If this level falls down, it is advisable to go in for pond fertilization so as to maintain an optimal plankton content in the water.

B) **Stocking:** In production ponds, fish fingerlings of 7-10 cm size or preferably the yearlings weighing 100-250g are stocked, after 7 to 10 days of initial fertilization. Before stocking, the fingerlings are acclimated with the water of the production ponds. Further, they must be given a dip treatment in 2% potassium permanganate solution in order to avoid parasitic infections. The stocking density varies from 3000 to 10,000/ha, depending on the fertility of water, species and size of fish cultured, culture period and type of culture practice. In Andhra Pradesh, catla, rohu and mrigal are commonly stocked in ponds in the ratio of 3:6:1 whereas in Bengal, the ratio is being 3:3:4. Recently in Andhra Pradesh most of the farmers resorted to stocking the ponds with catla and rohu (3:7 or 4:6 ratio) only.

In Andhra Pradesh, during the earlier phases of development, farmers used to stock exotic carps such as silver carp, grass carp and common carp along with Indian major carps. But, at present, both silver carp and common carp are not cultured because of the poor keeping quality of silver carp during transport and the low price these two species command in the market. However, in few farms, grass carp is being cultivated as secondary fish at low densities of 100-250 nos./ha.

C) Post-Stocking Management:

i) **Feeding:** Supplementary feed comprises mainly deoiled rice bran and oil cakes such as groundnut oil cake, mustard cake, cotton seed cake, soyabean cake, sunflower seed cake, etc. Generally fish are fed with a mixture of 70-80% deoiled rice bran and 20-30% oil cake daily during morning hours at the rate of 2 to 10% body weight of the fish stock. Sometimes vitamin-mineral mixture and antibiotics as a prophylactic dose are also added in the feed. Feeding is done through perforated polythene bags, tied to bamboo poles fixed in the pond in rows. About 10-15 bags are used per hectare. The bags are regularly removed and sundried before reuse.

ii) **Water Quality Management:** Water quality should be monitored regularly and maintain the optimum levels of physico-chemical parameters and plankton in order to achieve faster growth and healthier fish.

The optimum levels of some of the water quality parameters in carp culture ponds are as follows.

Water depth	-	1-2 m.
Water temperature	-	25-32°C
Water transparency	-	25-40 cm
pH	-	7.5-9.0
Dissolved oxygen	-	5 mg/l
Total alkalinity	-	60-300 mg/l as $CaCo_3$
Total hardness	-	60-300 mg/l as $CaCO_3$
Carbon dioxide	-	5 mg/l
Ammonia	-	Less than – 1.3 mg/l
Nitrates	-	upto 4.2 mg/l
Phosphates	-	1-2 mg/l
Plankton	-	2-3 ml/100 l of pond water, mostly with zooplankton.

Indiscriminate fertilization often results in algal blooms, followed by depletion of dissolved oxygen and mass mortality of fish. Inorder to maintain the dissolved oxygen at desired level, (not less than 3 mg/l) some farmers resort to aeration by fixing paddle wheels or water sprinklers in the ponds.

Algal bloom: Algal bloom formed by blue-green algae like *Microcystis, Oscillatoria, Anabaena* and *Arthrospira* is a common problem in fish ponds. They produce a surface scum which affects penetration of light to deeper waters. Such an algal bloom is largely due to the presence of excess nutrients and organic matter. A higher temperature and pH above 9 are also responsible for the appearance of algal blooms. Depletion of oxygen is often associated with the mass decay of the algal blooms.

The algal blooms are controlled either by chemical or biological methods. The chemical methods involve the addition of copper sulphate (1 ppm) or sulphuric acid (125 ppm) or simazine (0.5 ppm). The biological methods involve the introduction of the duck weed (*Lemna)* which forms a shade over the algae and thereby prevent their growth. Alternately, algal-feeding-fish such as silver carp may be introduced.

iii) **Growth and Health Care:** In order to assess the growth rate and health, fish should be sampled regularly at fortnight or monthly intervals using cast net or dragnet at different places of the pond. Properly managed ponds usually remain free from disease. Poor management of water quality, high stocking density, heavy fertilization, unhygienic bottom conditions and dietary imbalances are the major causes for slow growth and diseases in fish.

Diseases of fishes are classified as parasitic and non-parasitic. The parasitic diseases include those caused by bacteria, fungi, protozoans, worms, leeches and crustaceans and the non-parasitic disorders are due to nutritional and environmental problems. By proper diagnosis and treatment, most of the diseases can be easily controlled. Fish diseases and their remedial measures are given in Lesson 5-2.

D) **Harvesting:** Fishes are cultivated for a period of 9-12 months. During this grow-out period, catla attains 1.5-5 kg, rohu 0.5-2.5 kg and mrigal 1-3 kg weight, with 80-95% survival. Fish production varies from 2 to 17 tonnes/ha/year, with a normal yield of 3 to 4 tonnes/ha/year.

Harvesting of fish is carried out either once or 2-3 times during the grow-out period. At the time of complete harvesting, water is gradually drained to the level of trenches, situated along the periphery. The fish are then captured quickly by drag netting. Harvesting of the fish in the early morning or in the evening would be better to keep the fish in good condition for marketing. Harvested fish are packed with alternate layers of ice and fish in bamboo baskets or plastic crates and transported by road in trucks or by rail to Howrah market, the only major fish market in India. In local markets, the fish are sold in fresh condition or in iced condition.

2.2.6. SUMMARY:

1. For rearing the different life history stages of fish i.e. spawn, fry, fingerlings and adults, different types of ponds namely nursery, rearing and production ponds are used.

2. **Management of nursery pond** is most important for successful fish culture. Nursery pond is meant for growing hatchlings or spawn to fry stage for a period of about 15 days. Efficient fish culture needs special preparation of nursery ponds which harbour the tender spawn or hatchlings. Small seasonal ponds are preferred for nursery because their environmental conditions can be controlled easily.

A) **Pre-stocking management:** The nurseries should be dried in summer to facilitate mineralization of soil, removal of excess organic matter and elimination of aquatic weeds and predatory and weed fishes.

i) In undrainable ponds *predatory and weed fishes* and *aquatic weeds* are controlled by using different methods. The unwanted fish must be eradicated either by netting or poisoning. *Poisons* or fish toxicants of *plant origin, chlorinated hydrocarbons* and *organophosphate* pesticides are commonly used to eradicate the unwanted fishes and other predators. *Aquatic weeds* may be controlled by mechanical, chemical or biological methods.

ii) After eradicating the unwanted fishes and weeds, the pond bottom should be *limed* with quicklime (CaO) or agricultural lime ($CaCO_3$). The dose to be applied depends on the soil pH. Generally 300 - 500 kg/ha is required.

iii) The next step is *watering* the pond. Water should be let in through fine sieve arranged to the inlet inorder to prevent the entry of unwanted and predatory fish into the pond.

iv) Then the pond should be *fertilized* to increase the production of planktonic organisms which form natural food for the spawn. For this, usually application of cattle dung at the rate of 10 to 15 tonnes/ha 10 days before stocking the spawn and 5 t/ha seven days after stocking the spawn is suggested. The application of 5 t/ha of poultry manure also produces good amount of plankton in the pond. Inorganic fertilizers are also used along with organic manures. A mixture of 5 t/ha of cattle dung, 250 kg/ha of single superphosphate or 80-100 kg/ha of DAP and 250 kg/ha of ground nut oil cake has been found to yield adequate plankton in about 3 days. Addition of chemical fertilizers is normally avoided since it may lead to the development of algal blooms and oxygen depletion.

v) Indiscriminate fertilization often leads to the formation of *algal blooms*. These should be controlled by applying copper sulphate (1 ppm) or simazine (0.5 ppm) or by covering the pond surface with the duck weed *Lemna*.

vi) Sometimes after watering and fertilization of the ponds, predatory aquatic insects develop in the ponds. They are highly detrimental to spawn and fry. Hence, they should be eradicated from the ponds before stocking the spawn by repeated drag netting or by spraying oil emulsion using 60 kg of oil and 20 kg of soap per hectare.

vii) Just before stocking the spawn, water has to be checked. All the water quality parameters should be maintained at optimal levels for better survival and growth of the spawn.

B) **Stocking:** Nursery ponds are generally stocked at the rate of 5-6 million carp spawn/ha.

C) **Post-stocking management:** After 2 or 3 days of stocking the spawn, the plankton, the natural food of spawn gets depleted. Hence, artificial feeding should be resorted from second day onwards with rice bran and powered ground nut oil cake in the ratio of 1:1 at the rate of 2 to 4 times the initial body weight of spawn stocked.

In 15 days of nursing, the spawn grows to a size of 2 to 3 cm fry. The fry should be harvested in the early morning or late in the evening and transferred to rearing ponds. In the same nursery pond, 3 or 4 crops of fry can be raised in a season of 3 months.

3. **The management of rearing ponds** is almost similar to that of nursery pond. It differs from nursery pond mainly in its stocking with fry of different species. Rearing pond is also a seasonal pond, where the *fry* are grown to *fingerling stage* in about 3 months.

A) **Pre-Stocking Management** including the dewatering and drying, control of unwanted fishes, aquatic weeds, liming and fertilization are almost similar to that of the nursery pond.

B) **Stocking:** Fry of Indian major carps and Chinese carps are stocked at the rate of 2-3 lakhs/ha in the following ratios: Catla, rohu and mrigal at 1:2:2 ratio; catla, rohu, mrigal and common carp at 3:4:1:2 ratio; catla, rohu, mrigal, silver carp and common carp at 2:4:4:3:3 ratio.

C) **Post-Stocking Management:** Supplementary feed consisting of a mixture of rice bran and powered ground nut oil cake at 1:1 ratio is broadcasted everyday in pond or placed in bamboo baskets or earthen bowls as small balls in shallow regions of the pond. It is given @ 1% body weight of fish initially and then increased to 2-4%. After 3 months of rearing, the fingerlings are harvested and transferred to production ponds. During off-season, the rearing ponds can be used as production ponds.

4) **Management of production pond:** In production pond, fingerlings are stocked and grown for about 9-12 months until they reach marketable size. The production ponds are larger than the other ponds and the ideal size is 1 to 2 ha.

A) **Pre-stocking management** including the dewatering and drying, control of unwanted fishes, aquatic weeds, liming and fertilization are almost similar to that of the rearing pond.

B) **Stocking:** Fingerlings of 7-10 cm size or preferably the yearlings weighing 100-250g are stocked after 7-10 days of intital fertilization. The stocking density varies from 3000 to 10,000/ha with catla, rohu and mrigal in the ratio of 3:6:1 in Andhra Pradesh or 3:3:4 in West Bengal. In some farms, the exotic carps are also stocked along with Indian major carps.

C) **Post-stocking Management:**

i) Feeding: Supplementary feeding with a mixture of 70-80% rice bran and 20-30% oil cake is given daily at the rate of 2 to 10% body weight of the fish stock. In addition, vit-min-mix and antibiotics as a prophylactic dose are also given in the feed. Feeding is done through perforated polythene bags tied to bamboo poles fixed in the pond.

ii) Water quality: Water should be monitored regularly and maintain all the parameters at optimal levels in order to get higher yields. Indiscriminate fertilization, high temperature and pH often results in algal blooms followed by depletion of oxygen and mass mortality of fish. Hence, oxygen should always be maintained above 3 mg/l.

iii) Control of algal blooms: The algal blooms formed by blue-green algal members is a common phenomenon in fish ponds. They are controlled by the application of copper sulphate (1 ppm) or simazine (0.5 ppm) or sulphuric acid (125 ppm) in the pond. Biologically, they can be controlled by introducing algal-feeding fish like silver carp in the pond or by covering the surface water with the duck weed, *Lemna*.

iv) Growth and health care: Fish should be sampled monthly or fortnightly to assess their growth rate and health condition. Poorly managed ponds are prone to disease afflictions. The **parasitic diseases** are caused by bacteria, fungi, protozoans, worms, leeches and crustaceans. The non-parasitic diseases are due to nutritional and environmental problems. By proper diagnosis and treatment, most of the diseases can be easily controlled. However, prevention is better than cure.

D) **Harvesting:** Harvesting of fish may be complete or partial depending on the stocking density and marketing facility. During complete harvesting, water is drained so that all the fish are concentrated in the trenches or in the harvesting pit. Then they are captured by drag netting. Harvested fish are packed with ice in plastic crates or bamboo baskets for long-distance transport i.e. to Howrah market. In local markets fish are sold in fresh condition or in iced condition.

2.2.7. MODEL QUESTIONS:

1. Classify the carp culture ponds on the basis of their functional significance and briefly discuss their management.

2. Give an account of the management of carp nursery ponds.

3. Enumerate the management methods to be followed for maintaining production ponds.

4. Describe the steps followed for rearing carp from fry to fingerling stage.

5. Write notes on the

   a. Control of predatory and weed fishes in fish ponds.

   b. Algal blooms and their control in carp culture ponds

   c. Predatory insects of a culture pond and their control

   d. Supplementary feeding in carp culture ponds

   e. Importance of liming and fertilization of ponds in carp culture.

2.2.8. REFERENCE BOOKS:

Jhingran, V.G. 1991. *Fish and Fisheries of India.* Hindustan Publishing Corporation (India) Delhi.

Pillay, T.V.R. 1990. *Aquaculture Principles and Practices,* Fishing News Books, Ltd., Oxford.

Stickney, R.R. 1979. *Principles of Warm water Fish Culture,* John Wiley & Sons, Inc., New York.

Boyd, C.E. 1982. *Water Quality Management for pond fish culture* (Development in aquaculture and fisheries series 9) Elsevier science Publishing Company Inc., New York.

Dr. P. PADMAVATHI

LESSON - 2.3

EXOTIC FISHES OF INDIA: BREEDING AND CULTURE OF COMMON CARP

2.3.1. Objectives
2.3.2. Introduction
2.3.3. Common carp
- **A. Bionomics**
- **B. Breeding of common carp**
  - **a. Breeding technique followed in India**
  - **b. Breeding technique followed in Europe**
  - **c. Breeding technique followed in Indonesia**
  - **d. Breeding technique followed in China**
- **C. Culture of common carp**

2.3.4. Summary
2.3.5. Glossary
2.3.6. Model Questions
2.3.7. Reference Books

2.3.1. OBJECTIVES:

The purpose of this lesson is to

* know the exotic fishes of India, their source, purpose and year of introduction to India, and
* describe the breeding and culture of important exotic food fish, the common carp, *Cyprinus carpio*.

2.3.2. INTRODUCTION:

Some of the fishes found in India are not endemic. They are native of other countries, but introduced successfully into our waters to serve several purposes like food, sport and public health. These fishes are called exotic fishes. Some important exotic species found established in India are listed below.

Scientific name	*Common name*	*Source*	*Year of introduction*	*Purpose*
A. Food fishes:				
Carrasius carrasius	Golden carp, Crucian carp, English carp	England	1870	Experimental culture
Tinca tinca	Tench	England	1870	"
Osphronemus goramy	Gourami	Java and Mauritius	1916	"
Cyprinus carpio (German strain)	Common carp	Ceylon	1939	"
Cyprinus carpio (Bangkok strain)	Common carp	Bangkok	1957	"
Tilapia mossambica	Tilapia	Bangkok	1952	"
Ctenopharyngodon idella	Grass carp	Japan	1959	Experimental culture and weed control
Hypophthalmichthys molitrix	Silver carp	Hong Kong	1959	Experimental culture
Puntius javanicus	Tawes	Indonesia	1972	"
Clarias macrocephalus, *Clarias gariepinus* (African catfish) *Pangasius sutchi* and *Ictalurus* sp. (American channel catfish)	catfishes	South-east Asian countries	1990's	"
B. Game Fishes:				
Salmo trutta	Brown trout	England	1901	For planting streams, lakes and reservoirs
Salmo gairdneri	Rainbow trout	Ceylon and Germany	1907	"
Salvelinus fontinalis	Brook trout	Canada	1959	"
Oncorhynchus nerka	Sockeye salmon	Japan	1968	"
Salmo salar	Atlantic salmon	USA	1968	"
C. Larvicidal fishes:				
Lebistes reticulatus	Guppy	South America	1908	Mosquito control
Gambusia affinis	Gambusia	Italy	1928	"

Of the exotic food fishes listed in the Table, the following are more important from the view-point of fish culture: common carp, silver carp, grass carp, tilapia and gourami. In this lesson, the main focus is on the breeding and culture of common carp, *cyprinus carpio.*

2.3.3. COMMON CARP, *CYPRINUS CARPIO*:

Common carp is the most important exotic food fish in India. It is employed extensively for culture. The common carp, *cyprinus carpio* (Linnaeus), is native of the temperate regions of Asia, especially of China. Schaperclaus (1933) stated that it was a native of the river months, which open into the Caspian and the Black Sea. The earliest reference to the culture of common carp is from China as early as in 475 BC. It is thus autochthonous to China and Russia, though, according to Okada (1960), it originated from Central Asia and was introduced into China and Japan in the Oriental region and into Greece and Europe through Rome, in ancient times. The original distribution of this carp was confined to a narrow belt in Central Asia. But now it is found throughout the world. Although it is essentially a cold water loving fish, it has been acclimatized to a variety of tropical habitats. In India, the mirror carp was first introduced into Ooty lake in Nilgiris in 1939. Later this species was transplanted in several lakes and ponds at higher altitudes in different states of India. Mirror carp is an ideal fish for introduction in hilly regions where it thrives very well and breeds. The fish has also been reported to breed in the plains. The strain of scale carp brought by CIFRI, Cuttack Station from Bangkok in 1957 is found to procreate prolifically in the plains of India. It has been distributed by CIFRI to the various states of the country for culture. It is cultivated in the country singly as well as along with Indian major carps.

A. BIONOMICS:

Morphology: There are three varieties of the common carp based on the pattern of scaling (Fig. 1-1).

1. Scale carp, *Cyprinus carpio* var. *communis*: The body is fully covered with regularly arranged rows of scales. This is the original form, now extensively cultivated in the Far East.
2. Mirror carp, *Carpio* var. *specularis*: The body is covered unevenly with a few large and shiny scales. A large area of the body is, however, naked. This species is extremely variable.
3. Leather carp, *C. carpio* var. *nudus*: The body is devoid of scales i.e. naked except for a single row of degenerate scales along the base of dorsal and sometimes at the base of other fins.

There is also a variety with only one row of big scales on the lateral sides. The scale carp and the mirror carp are the varieties preferred for culture, mainly because of their faster growth rates.

Food and Feeding: The fish is voraciously omnivorous, accepts artificial feeds, efficiently converting the ingested food into flesh and grows very fast. It is non-predatory and feeds on vegetable debris, worms, insects, rotifers, crustaceans and planktonic algae. When cultured along with major carps, it competes for food mostly with mrigal and kalbasu. It is generally active in the evening in the marginal shallow waters.

Maturity, Spawning and Development: The size and age at first maturity of common carp vary under the climatic conditions of different countries of the world i.e. 0.5 to 5 years. In plains of India, the fish attains maturity within six months of hatching (15-20 cm), whereas in the upland lakes it takes almost a year to mature (35-45 cm). Breeding takes place throughout the year, the peak seasons being January – March and July – August.

Common carp naturally breeds in confined waters (ponds). Spawning occurs in shallow marginal, weed-infested areas. When weeds are in deeper waters, the fish breeds in areas where the weed growth approaches the water surface. Floating batches of weeds also make suitable spawning sites.

Fertilized eggs of common carp are small, spherical, demersal and adhesive. Diameter of the developing egg varies from 1.0 to 2.0 mm, depending on the size of the parents. Yolk is usually yellow to light brown. Embryos hatch out within 7 1/2 days at the water temperature of 12°C; in 3 1/2 days at a temperature of 20°C and within 2 days at 28°C to 32°C. The newly hatched out larva is 4.0 to 5.6 mm in length and has a prominent yolk mass. The newly hatched larva adheres to the leaves of aquatic plants by means of cement glands and remains in this condition until the yolk is partially absorbed. The yolk is absorbed within 2 to 6 days depending on water temperature. Then the post-larvae (6-7 mm) start normal movement and feeding. Within 12 to 15 days of yolk absorption, all fins develop the full complement of rays. The young ones (5-10 cm) feed largely on planktonic crustacea. They are hardy and can withstand transport. Therefore this fish is ideal for culture in a wide range of habitats.

B. BREEDING OF COMMON CARP:

As the common carp breeds naturally in confined waters, several methods of propagating the species have been developed in different areas. The simplest one is the uncontrolled breeding in communal ponds, with shallow marginal areas covered with grass or aquatic vegetation which serve as substrates for their adhesive eggs. There are four major breeding systems of common carp adopted in different countries of the world, namely in India, Europe, Indonesia and China. In other countries one or the other system or with their minor modifications are followed.

a. Breeding technique followed in India: In Indian technique, the male and female breeders are segregated at least 3 to 4 months prior to the breeding season and stocked in separate ponds. Breeders are regularly fed on artificial feed comprising a mixture of oilcake and rice bran in 1:1 ratio at 2-3% of their body weight. The feeding rate has to be carefully manipulated in order to maintain the breeders in a healthy condition without fouling the water. Fully mature breeders are used for breeding. Proper selection of brood fish is very important in obtaining best results in breeding as well as in later grow-out. Many farmers select the largest, fast-growing fish. Generally 2-3 kg breeders are used for breeding. Large fish may be more difficult to handle, but large females spawn more and larger eggs, and the hatchlings are also larger and survive better. About 100,000-150,000 eggs are produced per kg body weight.

Males and females can be distinguished by external features during the spawning season. A mature female possesses an almost rounded, soft and swollen abdomen (due to the developing ovaries) with the ventral ridge becoming obscure and the vent projecting into a small papilla-like structure. In the mature males, the milt runs freely through the vent when the abdomen is gently pressed. Chinese farmers identify older males from the tubercles on the sides of the head and on the pectoral and ventral fins.

Breeding is done either in 'hapas' or in cement cisterns or in the pond itself. For this purpose, a set of brood fish comprising one female and 2 or 3 males are introduced into a 'hapa', keeping the total weight of males nearly equal to the weight of the female. The breeding hapa is almost similar to that used for major carps except that the top flap is unstitched on three sides inorder to facilitate uniform distribution of egg collecting weeds. Common submerged weeds like *Hydrilla* and *Najas* are generally used as egg collectors, though 'Kakabans' made of coconut fibres are also used occasionally. These aquatic plants are washed thoroughly beforehand. Normally, about 2 kg of weeds are considered adequate per kg weight of female but, for larger fish weighing 3 to 5 kg, about 4 to 7 kg of egg collectors are required.

The best time for release of brood fish in the hapa is evening. Fishes generally spawn in instalments within 6 to 10 hrs after being released in the hapa. By morning the egg collectors, with millions of eggs, are gently transferred to hatching hapas. After the spawning is over, the brood fish are removed from the hapas and weighed. The difference in weight before and after spawning gives the weight of eggs released.

The weeds with attached eggs are removed from breeding hapa and thinned out to a number of hatching hapas. About 1 kg of egg collector carrying nearly 40,000 to 100,000 eggs can be put in a single hatching hapa. Four to five days after breeding, the weeds are removed carefully from the hapa. Then the spawn from the hatching hapa is sieved through a coarse mosquito-netting cloth to remove debris. For measurement, a small sieved aluminium cup of known capacity is used. The number of spawn per cup are determined at the rate of 400 spawn per ml. The spawn is then stocked in prepared nurseries.

b. Breeding technique followed in Europe: The Dubisch method of breeding common carp is followed in Europe. It comprises use of small ponds (15 m x 6 m) where grasses are grown on the bottom to a height of about 40 cm when the ponds are dry. Ponds are filled with water upto the tip of the grasses and common carp breeders are released in them. Common carp breeds when the temperature rises to 15°C. Each pond has usually one set of breeders comprising one female and two males. Breeding of common carp occurs in Europe from middle of March to July end. After the spawning is over, breeders are removed from the pond. About 7 days after spawning, when the hatchlings have reached the post larval stage, they are removed from the pond and released in prepared nurseries for rearing.

Though common carp naturally breeds in ponds, for acquiring control over breeding, the species is induced to breed through hypophysation in several parts of the world especially in Hungary, Israel, etc. In this technique, female breeders are first anaesthetized by MS 222 and their vents sutured. Then they are given intramuscular injections at the base of dorsal fin at the rate of 2.5 to 3.7 mg of dried homoplastic pituitary per kg body weight. The extract of pituitary is prepared in a solution containing 0.6 – 0.7% sodium chloride and glycerine in the ratio of 70:30. The sutured injected breeders are kept in water together with males in hapas or basins. Male breeders are also injected with pituitary hormone. When females become ripe for spawning (in 8 to 26 hrs at 28 to 15°C), they are stripped first. The female is stripped by gently squeezing the abdomen towards the tail and the eggs that flow easily are collected in bowls or basins. Then the males are similarly stripped for milt, which is collected over the eggs in the same container. Then the contents are mixed immediately with a feather or a plastic spoon. The adhesive nature of the egg makes them clump together and hamper proper fertilization. For removing the glutinous substance, the entire egg mass is treated for about 1 1/2 hours with a solution containing sodium chloride and urea (40 g Nacl and 30 g urea dissolved in 10 l water). When the eggs are fully swollen, they are treated with another solution, made of 7 to 10g of tannin in 10 l of water, for about 1-2 seconds. Both these treatments completely remove the sticky material from egg shells. Thereafter, the eggs are washed with freshwater and kept in simple double hapas or jars for hatching. The eggs hatch out within 2 – 7.5 days depending on the temperature.

C. Breeding technique followed in Indonesia: The most important method of breeding common carp in Indonesia is the Sundanese method. The Tjimindi, the Rantjapaku and Central Sumatra methods are variations of the Sundanese method. In these methods, different types of substrates or egg collectors are used in carp spawning ponds.

i) *The Sundanese Method*: This method is extensively used in Java and other parts of Indonesia. In this method, the three processes, namely, the maintenance of brood fish, the breeding itself and the hatching are done in separate ponds. Breeders are segregated sex-wise and kept in separate ponds or in the same pond screened into two. Breeders are fed artificially with rice bran, kitchen refuse, corn, etc. Spawning ponds are elongate, 25 to 30 m^2 in area having a hard bottom (not rocky) devoid of mud and silt. The pond is dried for a few days before filling. The pond is filled with clean water to a depth of 50-70 cm. Water is preferably introduced in the morning, 'kakabans' placed in position and the brood fish released in the afternoon. 'kakabans' in Indonesia are made of the dark horse-hair-like fibres of the 'indjuk' plants (*Arenga* spp.). The indjuk fibres are thoroughly washed and their thin layers are arranged breadth-wise in 1.20 to 1.50 m long strips which are pressed between two bamboo slats (4-5 cm wide and 150 to 200 cm long) and nailed together on two sides (Fig. 2-12). In the spawning pond, kakabans are placed in floating position slightly under the water surface. The number of kakabans required is calculated on the basis of the weight of female spawners. About 5-8 pieces of kakabans are required for kg weight of female spawners. After the spawners are introduced, a gentle flow of water is maintained in the ponds. The spawned eggs are first deposited by the fish on the lower side of the kakabans. As spawning continues, kakabans are turned over by the fish culturist when the lower side is full of eggs. When both the sides are fully dotted with eggs, Kakabans are removed from the breeding ponds. They are washed to remove any sticking mud, debris, etc., and then transferred to hatching ponds which are 20 times larger than the spawning ponds.

In the hatching ponds, kakabans are placed transversely on floating bamboo poles leaving a 5 to 8 cm gap between the fibres of the adjoining kakabans (Fig. 2-13). Wooden poles or cut banana stems are placed cross wise on the bamboo poles so that the egg mats are kept below the water surface. The hatching pond has a number of outlets at different levels to regulate the outflow of water. After the 7th day, spawn are fed on rice bran. Spawn are collected when 3 weeks old by gradual

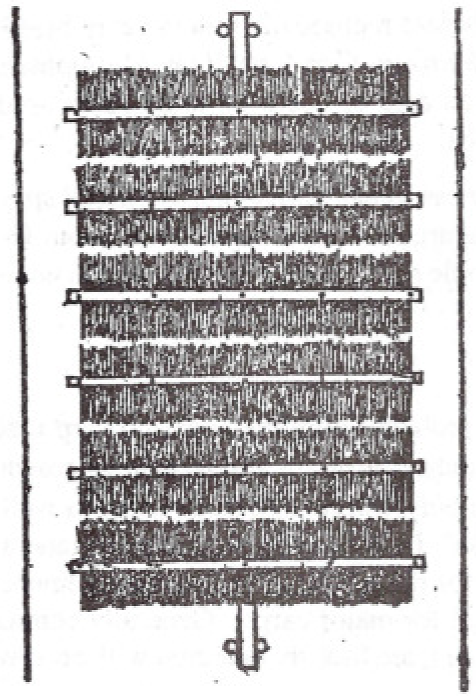

Fig. 2-12. Arrangement of 'kakabans' in spawning pond.

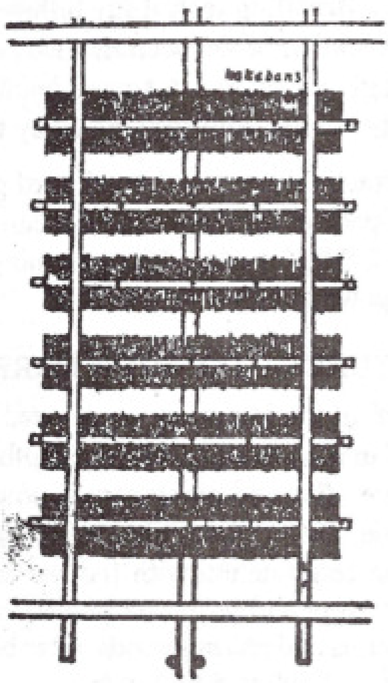

Fig. 2-13. Arrangement of 'kakabans' in hatching pond.

draining of the hatching pond. An estimated yield of 15,000 to 20,000 fry/kg weight of female is obtained by this technique.

ii) *The Tjimindi Method:* This method is the same as the Sundanese method, except that the spawning pond is a small compartment situated at one corner of the hatching pond and is separated from it by a temporary dike. After spawning, breeders are transferred to the hatching pond through an opening in the embankment which is closed again. When the spawn is one week old, the separating bundh is cut open and the spawn is allowed to escape into the hatching pond. The spawn is harvested when 2 –3 weeks old.

iii) *The Rantjapaku Method*: This method is similar to the above method except that the bottom of spawning compartment is constructed at a level higher than that of hatching pond and is made of sand-gravel. The bundh separating the spawning pond from the hatching pond is made of stones. The spaces between stones allow the spawn but not the breeders to pass into the hatching ponds. Newly cut floating grass covering the surface is used to collect the eggs. Spawn are collected when 3 weeks old.

iv) *The Central Sumatra Method:* In this method, instead of 'kakabans', indjuk fibres are scattered in the spawning ponds of about 5 m^2 area for the brood fish to attach their eggs to them. After spawning is over, breeders are removed from spawning pond. In this method, spawn are collected when only 5 days old.

D. Breeding technique followed in China: The Chinese method of common carp breeding is a modification of Dubisch method, using weeds like *Eichhornia, Ceratophyllum, Myriophyllum,* etc., as egg collectors. A square bamboo frame enclosing an area of about 10 to 25 m^2 is used to prevent the weeds from straying away from the spawning area.

Israeli farmers use branches of pine, casuarina or cypress as egg collectors. Artificial spawning mats made of synthetic material can also be used. The mat area needed as substrate is about 10 m^2 for every 2-3 kg females. The spawning mats are easy to handle and it is easy to estimate the number of eggs spawned.

C. CULTURE OF COMMON CARP

Of all the important carps used in aquaculture, it is probably only the common carp that is produced in monoculture, whereas both Chinese and Indian major carps are almost always grown in polyculture. Even common carp is now increasingly used in polyculture with other carps as well as with tilapia, tawes, gouramies, rainbow trout and grey mullet. In India, common carp is generally cultured in combination with Indian carps. The techniques for the preparation and management of nursery, rearing and grow-out ponds are same as that adopted for major carps. Generally common carp nurseries and rearing ponds, after being cleared of predators, are heavily manured with cowdung at the rate of 2,500 to 5,000 kg/ha.

Many fish farmers adopt the system of multiple stocking, which involves stocking fry, fingerlings and young adults belonging to different size-groups in the same pond, in order to utilize the food resources more efficiently. This practice involves periodic harvesting of the marketable fish and in some cases even additional stocking. There is also the practice of multi-stage stocking which consists of stocking fish in progressively larger ponds as they grow in size, reducing the stocking rates as required. Several stocking rates and grow-out practices are in use in different areas.

The growth rate of common carp differs greatly in accordance with the environmental factors such as temperature, availability of food, stocking density, supply of artificial feed, etc. In India, at a stocking density of 2,500/ha, the growth of common carp in manured ponds without and with artificial feeding works, on an average, to 600 to 800 g and one kg, respectively in the first year. The fish attains an average weight of 1.5 to 2.0 kg in the second year.

In East European countries, because of climate conditions, it generally takes three years to grow the fish to the preferred market size of 1 to 2 kg. In fertilized ponds with artificial feeding, the common carp attains 30 to 100 g at the end of the first summer, 250 to 700 g at the end of the second summer, and the marketable size of 1.0 to 2.0 kg at the end of the third summer. Stocking densities vary from 500 to 1200 fish per ha. In Israel, common carp reaches the weight of 500 to 700 g in 3 to 4 months when fish are reared in ponds at a stocking density of 2000 to 2500/ha. Ponds are manured heavily and the fish fed artificially.

2.3.4. SUMMARY

1. The fishes which are not native and brought to our waters from other countries are called exotic fishes. Several fishes serving food, game and public health purposes are found established in water bodies of India.

2. Common carp is the most important exotic food fish cultured in India. Though it is a native of the temperate regions of Asia (China), it is now widely distributed throughout the world.

3. There are three recognized varieties of common carp: the scale carp (*C. carpio* var. *communis)*, the partially-scaled mirror carp (*C. carpio* var. *specularis*) and the virtually scaleless leather carp (*C. carpio* var. *nudus*). In India the mirror carp was introduced into Ooty lake in Nilgiris in 1939 and scale carp at Cuttack in 1957.

4. Common carp is a voracious omnivore and grows very fast. It feeds on vegetable debris, worms, insects, zooplankton and planktonic algae.

5. Common carp attains maturity at six months to five years depending on the climatic conditions. In India, it matures from six months in plains to one year in uplands.

6. Common carp naturally breeds in confined waters. Spawning occurs in shallow marginal, weed-infested areas. Fertilized eggs are small, spherical, demersal and adhesive. The eggs hatch out within 2 to 7.5 days, depending on the temperature. The hatchlings subsist on yolk for 2 to 6 days. Then the post-larvae start movement and feed on external food, largely on planktonic crustaceans.

7. As the common carp breeds naturally in ponds, several methods of propagating it have been developed in different countries. In India, breeding is done either in hapas or in cement cisterns or in the pond itself. Common submerged weeds like *Hydrilla* and *Najas* or kakabans made of coconut fibres are used as egg collectors. Fishes spawn in instalments within 6 to 10 hrs after being released in the hapa or pond. The weeds with attached eggs are removed from breeding hapa and kept in hatching hapas. About 1 kg of egg collector carrying 40,000 to 1,00,000 eggs can be put in a single hatching hapa. The eggs hatch in 4 to 5 days, then the weeds are removed carefully from the hapa. The spawn is then stocked in prepared nurseries.

8. In Europe, the Dubisch method of breeding is followed. In this method small grass grown ponds are used for breeding the carp. After spawning, breeders are removed from the pond. After 7 days of spawning, the post-larvae are removed and released in prepared nurseries.

9. For controlled breeding, the carp is induced to breed through hypophysation in several parts of the world. The breeders are given 2.5 to 3.7 mg of dried homplastic pituitary per kg body weight. When the females become ripe for spawning (in 8 to 26 hrs), they are stripped and the eggs are collected in a basin. They are fertilized with milt stripped from males. For proper fertilization, the adhesive substance on the eggs in removed by treating them with a solution of sodium chloride and urea. When the eggs are fully swollen, they are treated with another solution made of tannin for 1-2 seconds. Then the eggs are washed with freshwater and kept in double hapas or jars for hatching.

10. In Indonesia, Sundanese method of breeding carps is in practice. The other methods used are the Tjimindi, the Rantjapaku and Central Sumatra methods which are variations to the Sundanese method. In Sundanese method, 'kakabans' made of indjuk plant fibres are used as egg collectors in spawning ponds. When both sides of the kakabans are attched with eggs, they are transferred to hatching ponds. Spawn are collected from hatching ponds when they are 3 weeks old.

11. In Chinese method of common carp breeding, weeds like *Eichhornia, Ceratophyllum, Myriophyllum*, etc., are used as egg collectors. Israeli farmers use branches of pine, casuarina or cypress as egg collectos. Synthetic spawning mats can also be used as egg collectors.

12. Of all the carps used in aquaculture, common carp is the only one produced in monoculture. Even common carp is now being used in polyculture along with other carps and fishes like tilapia, gouramis, tawes, rainbow trout, etc. The techniques for the preparation and management of nursery, rearing and grow-out ponds are same as that adopted for Indian major carps.

13. Multiple stocking and harvesting and also multi-stage stocking practices are used in different areas. The growth rate of common carp depends on environmental factors, availability of food and stocking density. In India, at a stocking density of 2500/ha, the fish attains an average weight of 600 to 1000 g in the first year and 1 to 2 kg in the second year. In east Europe, because of cold climate, the fish grows to 1 to 2 kg in three years period. In Israel, common carp attains 500 to 700 g in 3 to 4 months.

2.3.5. GLOSSARY

Demersal eggs: Eggs situated or developing in the bottom of a water body.

Kakabans: Egg collectors made of indjuk plant fibres fitted in bamboo frames used in breeding ponds of common carp in Indonesia.

2.3.6. MODEL QUESTIONS

1. Give an account on the breeding and culture of common carp.

2. Describe the various breeding techniques followed in breeding the common carp in different countries of the world.

3. Write notes on
   a. Exotic fishes of India
   b. Kakabans
   c. Varieties of common carp
   d. Hypophysation in common carp

2.3.7. REFERENCE BOOKS

Jhingran, V.G. 1991. *Fish and Fisheries of India.* Hindustan Publishing Corporation (India) Delhi.
Pillay, T.V.R. 1990. *Aquaculture Principles and Practices,* Fishing News Books, Ltd., Oxford.

Dr. P. PADMAVATHI

UNIT – IV

LESSON - 4.4
CULTURE OF SEAWEEDS

4.4.1. Objectives
4.4.2. Introduction
4.4.3. Seaweeds in the coastal waters of India
4.4.4. Culture practices of seaweed
A. Vegetative propagation
B. Culture propagation using spores
4.4.5. Global cultivation of sea weeds
4.4.6. Summary
4.4.7. Glossary
4.4.8. Model-questions
4.4.9. Suggested reading

4.4.1. OBJECTIVES:

To learn the culture practices of seaweeds

4.4.2. INTRODUCTION

Shallow inshore waters of the sea support fairly good quantities of marine algae commonly referred to as the seaweeds all over the globe. Seaweeds are important economically and are cultured in shallow coastal waters. Global production of aquatic plants in 2000 is estimated to about 10.13 million tons accounting to about 22.1 percent of the world aquaculture production and is estimated to cost US $ 6.2 billion which forms 11% of the total aquaculture product value. Farmed seaweed production has been growing in the last decade and now accounts for 88% of the world seaweed supplies (FAO 2002). China is the largest producer of seaweeds through aquaculture.

Seaweed is known to be important in human nutrition. Seaweed Porphyra (Nori) is known to contain 35.6 percent of crude proteins in dried product. (Bardach et al., 1972). Vitamins A, B1, B2, B6, B12, C and Niacin are known to be very high. They are also known to contain high quantities of minerals such as calcium, iodine, bromine, some important trace elements and several bioactive substances. The best-known seaweed component of the seaweed industry is that of the phycocolloids; the gelling, thickening. binding, stabilizing, clarifying and protecting agents known as carrageenans, alginates and agars.

4.4.3. SEAWEEDS IN THE COASTAL WATERS OF INDIA

Coastal waters of India are known to be inhabited by the seaweeds and the estimates indicate that about one million tons of seaweed is available in the coastal waters. Of these red algae (Rhodophyceae), brown algae (Phaeophyceae) and green algae (Chlorophyceae) represent the commercially important seaweed. In India along the east coast, coastal waters off Visakhapatnam in Andhra Pradesh, from Rameswaram to Kanyakumari in Tamilnadu and along the west coast off Gujarat, Bombay coast, Konkan, Ratnagiri, Goa and Andaman and Nicobar Islands in the Indian Ocean are the potential areas for seaweed availability About 700 species of marine algae are reported from the Indian Ocean. Of these 200 species of algae are cultivated in different areas globally. . Of the global production of the seaweed about 93 % is constituted by four genera *Laminaria, Porphyra, Undaria* and *Gracillaria* . The following species of seaweeds are known to be occurring in the coastal waters of India in Tamilnadu.(Table –1.)

Table 1. List of seaweeds occurring along Tamilnadu Coast

A. Agarophytes

1. *Geliediela acerosa*
2. *Gracilaria edulis*
3. *Gracilaria crassa*
4. *Gracilaria corticata var. corticata*
5. *Gracilaria verrrucosa*

B. Alginophytes

1. *Sargassum wightii*
2. *Sargassum myriocustum*
3. *Sargassum ilicifolium*
4. *Turbinaria coroides*
5. *Turbinaria ornata*
6. *Turbinaria decurreus*

C. Carrageenophytes

1. *Hypnea muciformis*
2 *Hypnea valentiae*

(Source: MPEDA Hand Book on Aquafarming)

Studies carried out by Central Marine Fisheries Institute, Central Salt and Marine Chemicals Research Institute, and National Institute of Oceanography indicate that seaweeds commonly occurring in Indian coastal waters are red algae represented by *Geliediella acerosa, Gracillaria edulis, G.crassa, G.folifera, G.verrucosa, G. crassa, Hypnea valentine* and *Sargassum*.

To meet the increased demand for the aquatic weeds as food and for their byproducts, attempts have been made by the National Research organizations in India, to develop culture technology for the seaweed culture on a commercial scale. Culture of seaweeds is important to maintain a continuous supply of the raw material for the industry throughout the year.

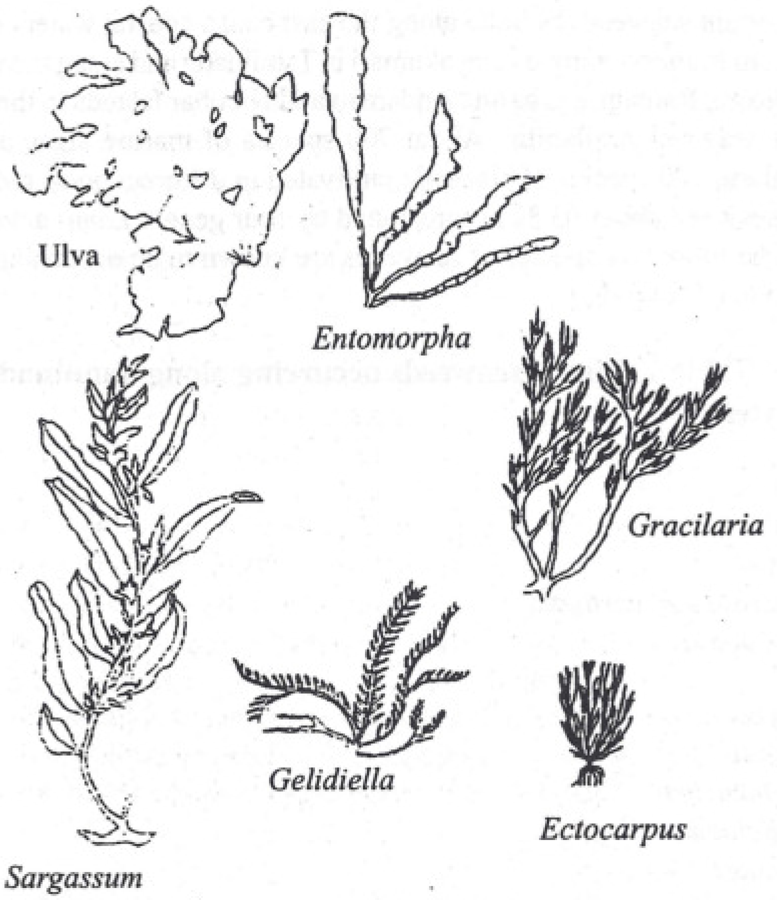

Fig. 4-2. Sea weeds

4.4.4. CULTURE PRACTICES

Seaweeds are chiefly marine and cannot withstand wide variations in salinity. Many of the edible species of seaweeds require temperatures between 10 and 20 C for rapid growth. They are present chiefly in the intertidal regions while some species are sub-tidal. Reproduction is by both sexual and asexual methods Specially, the red algae represent a biphasic – gametophyte and carposporophyte type of alternation of generations while others show triphasic with gametophyte, carposporophyte and tetrasporophyte phases. Asexual reproduction by spores occurs in the rather young stage of the leafy plants. Vegetative propagation is also a common practice among the cultivated seaweeds. The culture systems are mainly designed to collect the seed in the form of monospores by placing on the sea bed different types of spore collectors like bundles of twigs of concrete blocks or rocks for the collection of the spores. They are usually cultivated in the natural habitats by adopting two types of methods. The first method is the vegetative propagation of the seaweeds while the other method is by zoospores, macrospores, tetra spores and carpospores.

A. VEGETATIVE PROPAGATION

In this method fragments of the weed from the mother plants is utilized for cultivation. Along the Indian coasts Seaweeds such as *Gracillatia, Hypnea, Cystosiea, Horpomorpha, Caulerpa, Ulva* and *Acanthophora* have been attempted for culture in the coastal waters and bays. Central Marine Fisheries Research Institute and Central Salt and Marine chemicals Research Institute has carried out culture experiments on an extensive scale. These studies reveal that the sea weed *Gelidiella acerosa* can be successfully cultivated on coral stones and the other weeds such as *Gracillaia edulis, Hypnea musiformes* and *Acanthophora specifora* could be in long coir ropes and nets suspended in shallow coastal waters by floats. *Gracillaria edulis* has been cultivated in the inshore waters of f Gulf of Mannar and Palk bay near Mandapam in Tamilnadu state. The cultivation can be taken up from November to March in Gulf of Mannar and between June and September in Palk bay region

Seaweeds are cultivated on coir rope nets or rope nets made up of synthetic material and also on the nylon monofilament lines. These nets are hung in seawater between casuarina poles erected at some distance. Pieces of the seaweeds are inserted between the twists of the coir rope and are left in seawater. These twigs grow on the ropes. In 60 to 80 days the seaweeds are known to grow three times their initial weight. In this type of culture method, one kg of seed material is known to grow to a weight of 3kg per m2 of the net in about 60 days. Estimates show that in one hectare of area of the net surface (about 1000 nets) 30 tons of the seaweed..*G.edulis* can be harvested during each harvest and in a year seaweeds can be harvested six times accounting to a production of about 180 tons per ha per annum.

4.4.5. CULTURE METHOD USING SPORES:

Seaweed produces tetra spores and carpospores, which are utilized in the culture systems for propagation. Experiments were carried out using *G. edulis* by CMFRI. The mature plants maintained in circular cement cisterns with continuous water supply liberate the tetra spores and carpospores. They are grown in the laboratory to the germlings. These germlings are transferred to the coir ropes suspended by floats in the coastal waters. After one month young plants are developed which reach harvestable size in four to five month period.

Seaweeds are processed by sun drying them on the shore. The dry seaweed is processed to extract Agar, Carrageenan and Algin (Sodium alginate) in the processing plants.

4.4.6. GLOBAL CULTIVATION OF SEAWEEDS:

In China and Japan raft or rack culture is practiced for the culture of brown algae *Laminaria*. In the raft culture baskets are tied together in to basket rafts and are hung on ropes. The baskets contain small quantities of fertilizer to promote the growth of the weeds. Saprophytes are tied along the ropes along the sides of the baskets, which in course of time grow to marketable to size and are harvested.

In China a polyculture system has been developed for the culture of *Laminaria* in recent years. Scallops (Oysters) are grown on nets are suspended along the lines between seaweeds. Inorganic fertilizer is sprayed in the area to promote the growth of the seaweed. The seaweeds *Gracillaria* and *Caulerpa* are grown in ponds in Philippines and Taiwan. These are mainly cultivated for industrial use for the extraction of the byproducts. In North America seaweeds are grown in V-raceways flushed with seawater with compressed air-circulation.

4.4.6. SUMMARY:

Seaweeds are important as food and for extracting bye products such as Agar agar, Algin ad Carrageenan. Seaweeds are naturally available in coastal waters. The important Seaweeds are red algae, brown algae and algae. Seaweeds are cultivated in view of the demand for the bye products world wide in coastal water. They are cultivated through vegetative propagation and also through spores. In China a polyculture system along with the Scallops has been in practise, in Phillippines and Taiwan seaweeds are grown in ponds.

4.4.7. GLOSSARY:

Raft culture: Floating structures made of bamboo poles and kept afloat on water by buoys and floats. Ropes containing seaweed twigs are hung from these floating rafts in shallow areas of the sea for growing.

Vegetative propagation: propagation of the seaweeds through implanting small twigs in the twists of the ropes, which later grow in size

4.4.8. MODEL QUESTIONS:

1. Write an account of culture of seaweeds
2. Write about the global importance of sea weeds and add a note on culture.
3. Write Short Notes on:
    a. Agar agar
    b. Seaweeds as food
    c. Sargassum

4.4.9. SUGGESTED READING

Kaliaperumal, N. Sea weed Culture MPEDA Hand Book on Aqua Farming.pp. 9-24.
Pillay T.V.R. 1993 Aquaculture Principles and Practices, Fishing News 575 pp.

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UNIT – V

LESSON - 5.1

CULTURE OF ORNAMENTAL FISHES : FRESH WATER AQUARIUM KEEPING AND BREEDING OF ORNAMENTAL FISHES

5.1.1. Objectives
5.1.2. Introduction
5.1.3 Aquarium tanks and equipment
5.1.4. Preparing the aquarium for introducing the fish
A. Floor covering
B. Water
C. Assembling the tank components
D. Planting water plants in the aquarium
E. Introducing the fish
5.1.5. Indian ornamental fish fauna
5.1.6. Feeding and general care
A. Algae and their control
B. Changing water
C. Introducing new fish into the tank
D. Catching fish in a tank
E. Care of the aquarium plants
5.1.6. Breeding and rearing
5.1.7. Diseases
5.1.8. Summary
5.1.9. Model questions
5.1.10. Reference books

5.1.1. OBJECTIVES

The present lesson objectives are :

* To describe how to set up an aquarium
* Breeding and rearing of Ornamental fishes
* To describe information about types of feed and general care
* To describe about diseases and their control

5.1.2. INTRODUCTION

There are approximately 26,000different species of fish recognized by ichthyologists in a wide range of habitats. Human interest in fish was first aroused by the realization that they could be used as a source of fresh food. It was in the East, the ornamental fish keeping developed as a hobby with gold fish in a glass bowl. The colourful fishes have become a fancy for the people all over the world and hence fish keeping was started as a hobby with world interest. Keeping attractive and colourful and fascinating pet fishes at home in aquaria gives pleasure to the young and old alike. Also, aquaria become attractive and they add aesthetic beauty to the room in which they are kept. Nearly 95% of the hobbyists are from industrialized and developed countries from Europe and USA with relatively colder climate and less sunshine. The demand for ornamental fish is far better in colder regions where people usually live indoors.

The world ornamental fish industry has been growing steadily over the years to meet the interest of ornamental fish lovers. The development of tropical fish keeping as a popular hobby has occurred almost exclusively during the twentieth century. Prior to this, difficulties were encountered by ornamental fish trade due to slow transport. Rapid development of the technology of the 21st century is really a boon to this trade and especially air transport system which revolutionalized this industry by making it possible for the fish to be flown long distances in a relatively short space of time and to arrive at their destinations in good health.

Fish keeping is more popular in USA followed by European countries like Britain, Germany, Belgium, Italy, and Netherlands. Fish keeping is also popular in Japan, China, Australia, South Africa and other countries. About 85 % of the market for ornamental fishes is of fresh water origin and the rest is of marine ornamental fishes, which are of high value items and invertebrates and brackish water fishes. Countries supplying the world market with ornamental fresh water fish by far outnumber those providing with marine fish. About 80% fresh water ornamental fish in the market comes from South East Asia with Singapore and Hong Kong as its principal suppliers. Japan provides with largest supply of cold-water ornamental fish. Tropical fresh water ornamental species from South America are supplied by Brazil, Columbia, Peru, Venezuela, and Surinam and that of African are supplied mainly by Tanzania. The wild fresh water species from South East Asia are mainly supplied by Indonesia, Malaysia and Thailand and a few are supplied by Sri Lanka and India. But, certain species of Indian ornamental fishes have high demand in the world market and get and excellent price because they are in short supply and not easy to breed. Importers all over the world are eager to find supplies of rare and new species of ornamental fish to keep up with the demand of the most sophisticated hobbyists and scientists.

5.1.3. AQUARIUM TANKS AND EQUIPMENT

Aquarium tank is a means to display fishes that can live in comfortably. Aquarium tanks could be of different types and sizes. They can be made of iron or aluminium angles, Wooden or steel frames with glass panels of suitable thickness. Fibre or plastic panels too can be used but unfortunately the plastic sides scratch easily and become unsightly with debris and even algae accumulating in the depressions.

The dimension of the tank that too the length and width which give rise to the surface area of the water is important because this is where atmospheric oxygen diffuses into the water. If the depth is more relative to its length and width, then the water may contain insufficient oxygen to support the fish when they are in large number. Although deep tanks are necessary for large, tall fish like angelfish, care should be taken to see that proportionate length and width is maintained. A tank that is stocked to its maximum limit at the outset will soon be overcrowded as its occupants increase in size. Aquarium tanks of various sizes are available commercially. Taking the room size into considerations general recommendations for the tank size is – 100cm X 40cm X 40cm with 5-6 mm thick glass panels for a medium size living room and 60cm X 40cm X 30cm with 4-5 mm thick glass panels for smaller room.

Absolute recommendations as guidelines are given for the volume of water to be allowed per unit length fish. It is easy to calculate the volume of the tank using metric dimensions. To obtain the tanks capacity in litres, multiply the length by the width by the depth in centimeters and divide the total by 1000. For small fish 1° - 2 litres per centimeter should be adequate or approximately 1 gallon per inch using imperial units. For example, 30 litres water will support fish whose combined lengths do not exceed 15 cm (6 in) (10% of the total volume of the tank should be allowed for decoration and the remaining can be used as functional capacity). Circular models and bowls have narrow neck and when filled to the top the surface area gets much reduced and hence the fish suffer from oxygen deficiency and when only half filled although much surface area is available, the volume of water available for swimming gets much reduced. So, only rectangular tanks are the best ones.

The tanks should be provided with suitable type of hoods corresponding with specific sizes of tanks. They keep evaporative loss to the minimum and help to reduce heating costs (in colder regions) since the air above the water is maintained at a relatively constant temperature. The hood prevents more active fish like Oscars from jumping out of the tank and reduces contamination of water by house dust. Majority of hoods include space for an electric light often with a reflector (surrounding area) to spread the light evenly over the water surface. Fluorescent tubes should be preferred for illuminating the aquaria. The usual incandescent domestic light bulbs do not last long as they are designed to hang vertically rather than horizontally and they also give out unwanted heat and to the surface of the water. Although expensive tubes which emit light from the red and the blue parts of the spectrum thus closely imitating natural light are of great value especially above a planted tank.

Aeration: Aeration is an optional requirement. Properly managed tank with adequate number fishes does not require aeration. If more number pf fishes and decorative dolls have to be maintained in aquarium an aerator or air pumps or air diffusers to bubble air through becomes a necessity to diffuse oxygen into the water and drive out the carbon dioxide from the water. An aerator circulates the water and the effective circulation helps to maintain constant temperature through out the tank. Noisy air pumps should be avoided. Movement of water in the tank also ensures that the debris and waste products from the fish can be removed via a filter. Pumps often have a dual role, forming a part of a filtration system along with aeration, so suitable powerful model should be selected. The diaphragm pump is a popular type used by many aquarists.

Methods of filtration: The purpose of filtration is to remove waste matter, which could otherwise build up and poison the tank inhabitants. Indeed biological filtration occurs naturally in properly established aquaria – the bacteria present in the gravel degrade waste matter and the aquarium take up and utilize the potentially toxic components such as ammonia, nitrite and nitrate. For this system to work effectively, the bacteria must have adequate oxygen, and the aquarium should not be over crowded and the fish should not be overfed as the surplus increases the contamination of the bacteria.

Mechanical filtration is less complex, as solid material is removed and retain when the water passes through the medium such as filter wool, which needs to be changed regularly to remain effective. Chemical filtration makes use of activated charcoal, which has a large surface area and absorbs dissolved organic waste products and other compounds into its many cracks and crevices.

Under gravel or sub-gravel filters placed on the floor of the aquarium and covered with gravel to a minimum depth of 7.5 cm (3in), acts as the filter medium must be relatively unobtrusive and inexpensive. The air pump must be left on continuously otherwise the beneficial aerobic bacteria suffers and the system breaks down. And the plants should be grown in plastic pots as the growing roots may block the pores affecting the efficiency of the under gravel filters.

Box filters are common alternative to the under water filter or can be used in conjunction with it. They can be fitted outside or inside in the corner of the tank.

5.1.4. PREPARING THE AQUARIUM FOR INTRODUCING THE FISH

The aquarium should be kept out direct sunlight, as the resulting excessive algal growth soon spoils the aquarium's appearance. The heat of the sunrays affect the temperature of the water and sudden changes of nature become harmful to fish. The aquaria should never be placed in close proximity to room heaters, refrigerators, air-conditioners, windows and doors where the temperature fluctuates significantly. A power point should be with in an easy reach of the tank and the site should be freely accessible for maintenance purpose. Tanks positioned at eye level are difficult to service.

A new tank should be washed first with salt water. Detergents or disinfectants should be avoided, as they are likely to prove toxic if any residues still remain after rinsing. Then the tank should be wiped with a clean cloth at the same time to make sure that there are not any minute silvers of glass, which could subsequently lodge, to ill-effect, in fish's gills. It is vital, that a secure base for the tank should be chosen. Whether or not a stand is used, if a polythene sheet is placed under the tank, it serves to counteract any unevenness in the surface that it is standing on.

Picturesque and scenic sheets of aquatic landscape can be used as backdrop to the aquaria. If the aquarium is used as room divider, background is not necessary.

Floor covering: Aquarium gravel is most common choice for the floor of the tank. A coarse grade with individual particles of about 3-4 mm (1/8 in) should be use especially when an undergravel filter is to be used. Adequate quantity of sand or gravel is needed to cover about 5-8 cm height at the bottom as this also provides required depth to hold the plants. River sand can also be used bur fine sand is not generally recommended as the water will not be able to circulate effectively between the granules. The amount of gravel required can be calculated roughly on the basis 1 kg per 4.5 litres (2 lb per gallon) of water. Artificially coloured gravel is popular and available in an array of colours but it is important to ensure that the dyeing agent remains fast in water.

Although gravel obtained from the aquarist shops has often been washed already it should be washed again to remove any remaining debris and treat it to ensure that no parasites other harmful organisms introduced into the tank with it. After washing the gravel or sand it should be transferred into a plastic bucket containing potassium permanganate solution. The gravel or sand has to be stirred thoroughly several times in the course of two days and it has to be washed repeatedly until the water is clear of any purple tinge.

Water: Water is the immediate environment for the fishes. Fresh and clear potable water of 7 - 8 pH, is recommended as suitable to maintain many fish without additional treatment. The pH is often vital for successful breeding of some of the fishes. If the tap water is chlorinated it has to be aerated overnight before it is added into the aquarium. The fish are very sensitive to any sudden alteration in the pH of water.

Assembling the tank components: After tank has been placed in position and the under gravel filter added, the gravel can be placed carefully in the aquarium. There should be a slope down towards the front so that subsequently any debris will be evident and a thicker layer of gravel at the back of the tank also provides a deeper substratum for plant roots and conceals pots if they are used. It is preferable to fill the tank at least half-full of water before putting the plants and other tank decorations. Water has to be poured carefully on to a plate located on the surface of the gravel so that the actual gravel base does not get disturbed.

To maintain an aquarium we require some ancillary equipment. A small hand-net made of muslin or soft nylon cloth has to be used to collect the fishes without injury. A square or rectangular nets will be suitable for average aquarium is necessary to fix aquatic plants without damaging their root system. To clean the algae from the glass a scrubber pad attached to a rod is required. A siphon tube is required to suck out the fecal matter, left over feed and plant debris from the aquarium floor. A filter is an optional requirement as it cleans the water by removing unwanted matter suspended in the water. An aerator and connecting tubes with control valves are required to aerate the aquarium water.

Planting water plants in the aquarium: Aquatic plants provide aesthetic beauty to the aquarium and create natural surroundings to the fishes. The provision of living plants in aquarium undoubtedly helps to maintain the biological balance of the environment. They utilize the nitrate produced from the breakdown of waste products by bacteria and are also involved in gas exchange, carrying out a process known as photosynthesis. During the day, plants take up carbon dioxide from the water, which in the presence of light, is used to produce carbohydrates for food and in return they give off oxygen to the tank water. At night, however, photosynthesis ceases and situation is reversed and plants utilize oxygen in minute quantities releasing carbon dioxide. Some plants are better oxygenators than others and this feature is directly related to the surface area of their leaves. Those with small leaves such as Java Moss are better in this respect than broad-leaved species.

Some of the aquarium plants are costlier than even aquarium fishes indicating their importance in the aquarium tank. A combination of four or five of the plants would be ideal for an aquarium. We can select from a range of plants from –

1. Java Moss – *Vesicularia dubyana*
2. Spike rush – *Acorus greamineus*

3. Lace plant –*Aponogenton undulates*
4. Fanwort - *Cabomba caroliniana*
5. Hornwort – *Ceratophyllum submersum*
6. Cryptocornes or Crypts – *Cryptocorne affinis, C. wendtii, C. nevillii, C. ciliata, C. griffithii*
7. Amazon sword plant – *Echinodorus intermedius, E. bleheri, E. cordifolius, E. tenellus*
8. Hydrilla – *Hydrilla verticillata*
9. Water star - *Hygrophila polysperma, H. difformis*
10. Mint – *Ludwigia natans,*
11. Water milfoil – *Myriophyllum* spp.
12. Arrowhead – *Sagittaria latifola, S. subulata*
13. Tape grass – *Vallisneria spiralis, V. s. torta, V. gigantean*

Some of the floating plants are –

1. Banana plant – *Nymphoides aquatica*
2. Water sprite – *Ceratopteris cornuta*
3. Indian water fern or Sumatra Fern – *Ceratopteris thalictroides*
4. *Salvinia auriculata.*

Introducing the fish: After assembling and setting an aquarium it is better to add the fish at least after a week as during that time plants get an opportunity to become established. It is preferable to purchase all the fish for a tank simultaneously from same source to avoid problems such as bullying. The fish are usually sold in plastic bags with relatively small amount of their tank water and large volume of air to ensure that they have sufficient oxygen for their journey.

The bag containing the fish should be floated in the tank water for a period of time to enable the water temperatures to even out before releasing the fish. The fish take a while to adjust to their move and should be watched closely for any signs of illness, which is especially likely to develop at this stage. Some fish such as Dwarf Rainbow Cichlids many undergo a loss of colour at first, but this is only a temporary change.

5.1.5. INDIAN ORNAMENTAL FISH FAUNA

There are several varieties of fresh water ornamental fishes, which are available in India, and these have great demand in Europe and America. Some of the important freshwater and brackishwater ornamental fishes of different groups in India are given below along with their distribution.

Barbs:

1. *Puntius amphibious* – Peninsular India up to Orissa and Rajasthan.
2. *P. arenatus* – Tamil Nadu.
3. *P. arulius* – Southern India (Kerala & Tamilnadu).
4. *P. bovanicus* – Tamil Nadu (Cauvery river system).
5. *P. carnaticus* - Tamil Nadu Cauvery and Krishna river system and Northeast Kerala.
6. *P. chola* – Through out India.
7. *P. curmica* – rivers of Western ghats and south India.

8. *P. denisoni* – Southeastern India.
9. *P. dorsalis* – Cauvery and Krishna river systems and also from Rajasthan.
10. *P. filamentosus* – Cauvery river system and Goa.
11. *P. gelius* – Eastern and Northeastern India.
12. *P. jerdoni* – Rivers of South India.
13. *P. kolus* – Rivers of South India and Madhya Pradesh.
14. *P. melanumpyx* – Western ghats and Travencore hills in Kerala and Goa.
15. *P. narayani* – Tamil Nadu and Karnataka.
16. *P. neilli* _ Thungabhadra and Krishna river systems of Andhra Pradesh.
17. *P. parrah* – South India.
18. *P. phutunio* – Northeastern India.
19. *P. pulchellus* – Karnataka.
20. *P. rossipinnis* – South India (Pondicherry).
21. *P. sarana* – Throughout India except Southern India.
22. *P. subnasutus* – South of Krishna river.
23. *P. terio* – Northeastern river systems.
24. *P. thomassi* – Karnataka.
25. *P. ticto punctatus* – Kerala and Coramandal coasts.
26. *P. ticto* – Through out India.
27. *P. vittatus* – Southern India and also Rajasthan.

Loaches:

1. *Botia almorhae* – Kashmir, Almorha (Maharashtra) and Khasi Hills (Karnataka) and Uttar Pradesh.
2. *B. Dario* – Northeastern Indian rivers and Uttar Pradesh.
3. *B. histrionica* – Uttar Pradesh, Manipur and Assam.
4. *B. Hymenophysa* – Manipur.
5. *B. lohochata* – Northeastern India, Punjab, Himalayas, Valleys of Ganges and Indus river system
6. *Noemacheilus bimachari* – Cauvery river system and Karnataka.
7. *N. botia aureus* – Ganga, Yamuna and Brahmaputra river systems.
8. *N. evezardi* – Scattered allover India.
9. *N. pulchellus* – Bhavani and Cauvery river system.
10. *N. rupelli* – Krishna river system and Poona.
11. *N. shimogensis* – Karnataka (Thunga river).

Cat fishes:

1. *Ailia coila* – From larger rivers of Northern India to Krishna river system of South.
2. *Ailia punctata* – Ganga and Yamuna and Indus river systems.
3. *Batasio batasio* – Assam, North Bengal and Kerala.
4. *B. tengara* – North Bengal.
5. *Conta conta* – Brahmaputra river system.
6. *Gagata cenia* – Bengal, Orissa, Yamuna, Ganges and Indus river systems.
7. *Somileptes gongota* – Northeastern river systems.

8. *Nangra punctata* – West Bengal.
9. *Nangra viridescens* – Brahmaputra tributaries and Yamuna river system.
10. *Nangra itchkeea* – River systems of deccan plateau.
11. *Mystus tengara* – Northern and Northeastern river systems.
12. *Mystus vittatus* – Cosmopolitan in distribution (Fig. 1).
13. *Mystus cavasius* - Cosmopolitan in distribution.

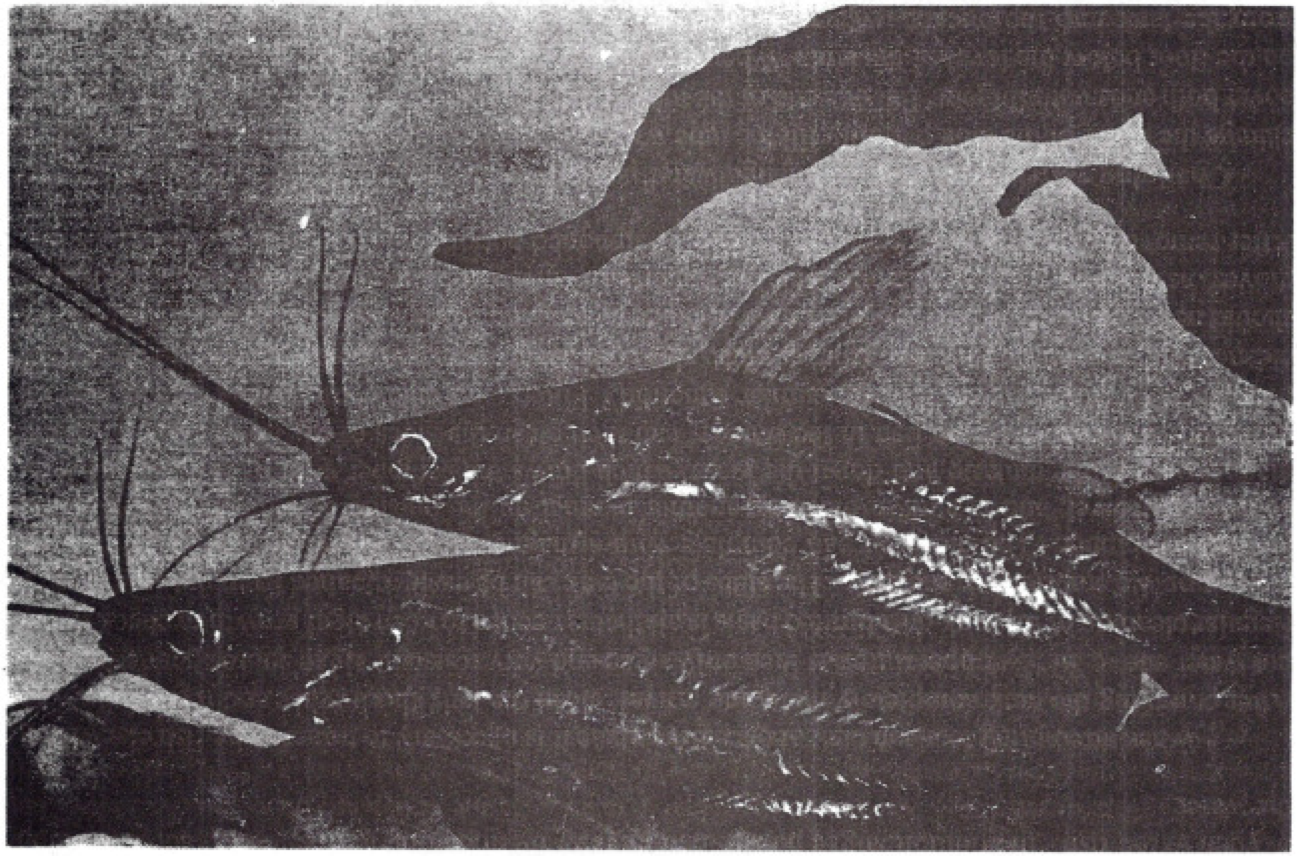

Fig. 1. *Mystus vittatus*

Half Beaks:

1. *Hemiramphus xanthopterus* – Kerala.
2. *Hemiramphus leucopterus* – Near Mumbai.

Mud Perches:

1. *Bais badis* – Northeastern river systems.
2. *Nandus nandus* – Northeastern India.

Paradise Fish:

1. *Macropodus cupanus* – Kerala.
2. *Macropodus cupanus dayi* – Kerala, TamilNadu and Karnataka states.

Noble Fish:

1. *Ctenops nobilis* – Northeastern river systems.

Gourami:

1. *Colisa chuna* – West Bengal and all Northeastern river system.
2. *Colisa lalia* - Northeastern river system.
3. *Colisa fasciata* – Coromandea coast as far South up to River Krishna , Ganges systems and all rivers in Northeastern states.

Murrels:

1. *Ophiocephalus punctatus* – Throughout India.

Puffer fishes:

1. *Tetradon cutcutia* – River systems of West Bengal, Orissa and Assam.

Pipe Fishes:

1. *Syngnathus kalyanensis* – Kalyan (Maharashtra).
2. *S. argyrostictus* – Tamil Nadu and Goa.
3. *S. spicifer* – Throughout India.

Glass Fishes:

1. *Chanda baculis* – River systems of Orissa, West Bengal, Uttar Pradesh, Bihar and Punjab.
2. *C. nama* – West Bengal.
3. *C. ranga* – Assam and Northeastern river systems.
4. *C. thomassi* – Kerala.

Knife fishes:

1. *Notopterus notopterus* – Cosmopolitan in distribution especially Northern parts.
2. *Notopterus chitala* - Cosmopolitan in distribution especially Northern parts.

Spiny eels:

1. *Macrognathus aculeatus* – Throughout India.
2. *Mastacembelus pancalus* – River systems from Northeastern parts up to south but not south of Andhra Pradesh.
3. *Mastacembelus armatus* – River systems of Northeastern state (Fig. 2).
4. *Mastacembelus guentheri* – Kerala and Assam.

Flying Barbs:

1. *Esomus danricus* – Throughout India (Fig. 3).

Rasboras:

1. *Rasboras danioconius* – In all river systems.

Zebra Fishes:

1. *Danio devario* – Northern and Northeastern river systems.

Fig. 2. *Mastacembelus armatus.*

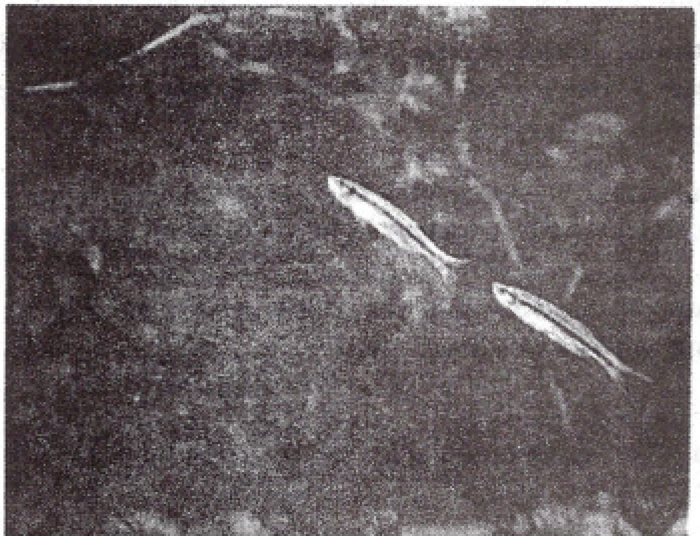

Fig. 3. *Esomus danricus.*

2. *Danio malbaricus* – West coast of India especially Northern Kerala.
3. *Danio aequipinnatus* – Himalayas at Darjeeling and whole Assam, Naza and Goa Hills and Deccan plateau.
4. *Danio dangila* – Bengal, Bihar and Himalayas at Darjeeling.
5. *Danio fraseri* – Rivers of Deoaliarea in Maharashtra.
6. *Danio naganensis* – Naga hills in Manipur.
7. *D. neilgherriensis* - Nilgiri hills in Tamil Nadu.
8. *Brachydanio rerio* – From Bengal to as low the Coromandel coast upto Machilipatnam in Andhra Pradesh.

Chilwas:

1. *Chela dadyburjori* – Goa, Cochin(Kerala) and Nagercoil (Tamil Nadu).
2. *Chela laubuca* – River systems of Andhra Pradesh, Orissa, West Bengal, Madhya Pradesh and Assam.

Killi fishes:

1. *Aplocheilus lineatus* - Coorg and Wynaad down the Malbar Coast.
2. *Aplocheilus panchax* – Orissa, Bengal, Andaman and Nicobar islands.
3. *Aplocheilus nibrostigma* – Throughout India.

Hill trouts:

1. *Barilius barna* – Assam, Ganges and its Branches and up to Bengal and Orissa.
2. *Barilius shacra* – Haridwar down the valley of the Ganges and assam.
3. *Barilius bendelisis* – Assam and Himlayas through India as far as the western ghats but not from Malbar and Canara Coast.
4. *Rohtee cotio* – throughout India except the Malbar Coast and South of the Krishna.

Calbasu:

1. *Labeo calbasu* – River systems of Punjab, Kutch, Deccan Southern India and Malbar from Krishna through Orissa and West Bengal.

Scats:

1. *Scatophagus argus* – Southern India.

5.1.6. FEEDING AND GENERAL CARE

In their natural habitat, fish eat a range of foods and their diet is often influenced by seasonal availability. Feeding fish in the aquarium is not difficult and now, a wide range of prepared, readymade and artificial foods are available, containing all the ingredients necessary to keep the fish in good health. There is no risk of introducing disease to the tank occupants using such food. Basic staple diets are manufactured in the form of tablets, flakes, powder, granules and floating pellets. Live foods fed to the fish are invertebrates, which occur naturally in water or cultivated or collected from other environments. Two most popular aquatic livefoods for fish are Daphnia, water fleas and tubifex worms, both of which are available at aquarist shops. Aquatic beetles and gnat larvae from stagnant pools and water taps can also be fed to the fish. Although fish undoubtedly appreciate such items, care should be taken to see that they are properly washed as they can propagate diseases and some may cause potential health hazard. Aquatic beetles for example can attack all fish and Hydra, can destroy a large numbers of fry in a short period of time by means of its stinging tentacles.

Non-aquatic livefood either cultured or obtained also can be fed to the fish in aquarium. Non-aquatic livefood includes Whiteworms (*Enchytraeus*), Earthworms, Redworms (*Dendrobina rubica*), Fruit flies (*Drosophilia*), Mealworms and whole worms. But, they should be cultured in hygiene conditions and in sterile media.

Many fish, if given opportunity take vegetable matter as part of their diet. Certain aquatic plants, such as Java Moss are particularly attractive to fish. Algae in the tank are another source of food often favoured by mollies, loaches and catfish amongst others. Boiled lettuce or spinach could be provided as an alternate in a newly established growth. Duckweed (*Lemna* species), which floats on the water surface, can be included in tanks for the Cichlids, since they often feed on this plant. Boiled oatmeal is another alternative food, which contains a significant amount of protein.

It is vital that fish are offered only a relatively small amount of food, which should be consumed by them within minutes of being placed in the tank. If completely consumed, then some more should be given. Fishes in the aquarium tank should be given smaller meals several times up to 4 times. Their digestive systems are not adapted to eating one large meal daily, as in wild they feed throughout the day. One of the most common errors of the novice is to overfeed the fish. Excess food pollutes the tank and makes the water dirty and depletes the dissolved oxygen and emits foul smell due to putrification. This keeps the fish under stress making them prone to infection. Certain fish, such as discus and angelfish, can be tamed sufficiently to eat out of the hand, especially when feeding takes place at regular times each day. It should be checked regularly the fish are all eating because loss of appetite is often sign of impending illness. Some fish, such as, angelfish and discus can lose their appetite for no apparent reason, however and may need to be tempted by a change of diet. And any fish, which persists in spitting out the food, should be removed from the tank, as they are likely to have an intestinal complaint.

In the communal tank, slower and shyer fish must be allowed an opportunity to feed unmolested, as feeding time is when bullying is more likely occur.

Algae and their control: Although the presence of algae in a tank can be of benefit to the fish by providing them with a readily available source of food, they also spoil the appearance of the tank, if their growth is not kept in check. There are more than 18,000 different species of algae known, some of which live in suspension in water causing it to be cloudy, while others colonize rockwork and the sides of the tank.

The major predisposing factor to excessive growth of green algae in a tank is too much illumination and aquaria, which are exposed to sunlight as well as artificial light often, suffer severely from an explosion of the algal population. A maximum of eight hours total artificial lighting per day is sufficient when no sunlight falls on the aquarium and this should be reduced if the aquarium is in an environment, which is naturally well lit.

As with plants, algae utilize oxygen from the water at night and it depletes the supply of oxygen to the fish. In addition, algae poison fish directly by liberating toxins, which accumulate in the water

When attempting to clean tank of excessive algae it is necessary to transfer the fish elsewhere. After emptying the tank completely including gravel, clean the tank thoroughly and repeatedly with hot water above 80 °C temperatures as then only algae and very resistant algae spores get destructed. Regular cleaning of the tank on a limited basis is all that is needed to keep algal growth in check rather than complete emptying of the tank. The sides of the tank can be easily cleaned from out side using a magnetic scrapper. The cleaning pad complete with a magnet is introduced at the top of the tank above water level, and is held in place by another magnet on the outside of the tank. Moving the magnet outside the tank up and down the glass, which draws the scrapper with it, and causing only minimum disturbance to the fish in the process can then clean the sides of the aquarium. Cleaning pads on long handles also perform similar function. Filters and connecting tubes should also be cleaned with appropriate set of brushes as algae also colonize in them, and disinfectants and detergents should never be used. While using clean razor blade to scrap algae deposits it is better to wear rubber gloves, as there is risk of contaminating the aquarium water with chemicals present on the hands. After removing algae deposits scraping have to be siphoned out of the tank.

Changing water: It is good to change water partially in the aquarium every month or so. To change the water of the tank partially fill the tube with aged water from a plant watering can and then cover both ends with fingers. Put one end of the tube in the tank and the other end into a bucket placed on the floor below the level of the tank. When fingers are removed at the both sides, water flows out from the tank into the bucket. When a portion of the water is removed we can follow the same procedure to fill in the tank with water of the same volume that has been removed from it. But the difference is the container from which we add water should be kept at a higher level than the tank

Introducing new fish into the tank: Introducing new fish into an established tank must be undertaken cautiously to minimize the risk of introducing disease and to protect new arrivals from bullying. A small quarantine tank is essential, where the fish can be acclimatized to new surroundings.

Catching fish in a tank: Small fish can be caught using a square or rectangular soft nylon or muslin net in an average tank. In case of large fish anesthetic should be added to their water to facilitate capture and to lessen the risk of injury. Stealth and patience are needed to catch fish in tank. Place net in the tank gently and move it in the direction of the fish to be caught. In a planted tank, it is easier to catch fish at the front where there are fewer obstructions such as rocks or plants, which could snag the net. Once fish is close to the net a sudden upward movement of net serves to retain it. Mouth of the net has to be covered to prevent fish from jumping out when the net is out of water. With minimum delay fish has to be transferred into a new environment. The fish should not be handled with hands to prevent damage to their skins.

If there is no urgency over catching them, a plastic bag baited with daphnia to attract fish can be introduced into the tank. This technique is less traumatic than direct netting. Another method, which is suitable for Spiny Eels (*Macrognathus aculeatus*) as they disappear into the substrate when threatened, requires a long rubber tube of suitable diameter. This should be placed on the floor of the tank and within few hours, the eels enter and hide in the tube, which should be then removed with them thus causing minimum disturbance to the remainder of the aquarium.

Care of the aquarium plants: If the plants do not appear to be thriving the amount of illumination, which the tank is receiving, should be increased. Those, which feed through their roots, such as cryptocornes and Echinodorus, may need an occasional provision of a pellet of fertilizer. For their use rabbit or guinea-pig droppings can be buried nearby in the substratum. A relatively common problem with *Echinodorus* and also *Vallisneria* especially, the giant form is that leaves turn white and then transparent with new growth appearing retarded. Ultimately the plants start to rot away. This disorder is known as chlorosis, and results from a specific lack of iron in their environment.

Algal contamination on plant leaves has to be removed by wiping carefully. The plants in aquarium should be thinned out occasionally so that fish get more swimming space and but it also prevents plants' growth becoming stunted. Surface plants such as duckweed have to be scraped of regularly using a net when their growth becomes luxuriant to allow sufficient light to penetrate through to plants rooted at the bottom of the tank.

Going away: Fish present less of a difficulty at holiday time than other pets, although adequate preparation must be carried out. A partial water change is likely to be beneficial and all equipment should be overhauled. It is important to check the electrical wiring. The average fish can probably fast for two weeks or so without ill effects. But, we can make use of now available vacation or weekend food blocks. These are placed in the tank and offer a constant release of food to the fish over a given period of time without contaminating the water. A friend or neighbour can be asked to come in and check the tank daily and it is vital to stress that the fish should not be overfed.

5.1.7. BREEDING AND REARING

Breeding fish in an aquarium can add greatly to the enjoyment of keeping them. While certain species like guppy, can be considered free breeding, there are others which present much more of challenge for the determined aquarist. There are two types of breedings in the ornamental fishes viz., egg layers and livebearers. Among the egg layers the method of breeding differs from family to family, such as in families *Cyprinidae, Anabantidae, Characidae*, segregation of males and females prior to breeding helps for increased fecundity and higher fertilization. Among the cyprinids such as gold fish, koi, etc. artificial breeding techniques such as hypophysation and hand stripping method can be applied for desirable results along with selective breeding by culling the stock having undesirable characters.

While the eggs of gold fish are adhesive, those of Characin are demersal. It is, therefore, necessary to remove the breeding pairs after breeding. Among anabantids such as Betta sp., Gourami sp., forming the most important group of aquarium fishes, has tendency to prepare a bubble nest and deposit the eggs up to yolk absorption stage of hatchings whereas in the egg laying family like Cichlidae, the males and females select their mate and need privacy for breeding. The pair lays the eggs on the cleaned substratum and guards till fry stage. This unique parental care ensures full protection to the babies from the predators till the fry stage. While raising the fry of the egg layers special care is necessary as infection can kill the tiny hatchlings. To reduce the rate of infection, good quality filtered and oxygenated water is necessary. Once the hatchlings become free swimming after the yolk sac absorption, selective food organisms of appropriate size such as culture of infusoria containing mainly paramecia, freshly hatched brine shrimp nauplii are most ideal. The fry of cyprinid varieties can be fed directly on the small-scale zooplankton or micro worms, detritus and faecal matter etc. Next stage of rearing fry is after its growth for a week. It needs larger space, hence it must be moved to a larger aquaria, cistern, plastic pool or nursery pond where it is grown to 3-4 centimetre size and is ready for sale. The varieties suitable for the mass rearing at indoor scale are small Characins, Puntius sp., Cichlids, Anabantids etc. Also the varieties like white cloud minnows, Zebra danio, leapord danio etc. can be bred on community basis on mass scale.

The livebearer group of aquarium fishes belongs to the family *Poecilidae,* which covers the most popular varieties like Guppies, Swordtails, and Mollies Platies etc. These have distinct differentiating characters between males and females. The males are brighter in colour and have a characteristic gonopodium. In most of these species a single copulation provides enough sperms to fertilize several batches of eggs. The female gives birth at approximately four weeks interval. The size of the young is not affected by the size of the mother. Mating in livebearers is promiscuous. Any male will mate with any female. It is better to have extra females, as one male may pursue a single female too vigorously without giving any rest. For controlled breeding, the sexes should be isolated shortly after birth to ensure virgin females.

No special conditions or preparations are required for breeding livebearers. The well water with hardness or little brackish water is quite suitable for livebearers. The babies are eaten by their parent, as well as by other fishes as soon as they arrive. Heavy planting together with floating plants may serve as refuge for some of the young or breeding and nursery traps which fit into aquarium help babies drop down towards the bottom before they are noticeably gravid. Number of young born to female livebearers can be ranged between 4-200 or more. The fry / babies released by livebearers swim freely and can eat directly the zooplankton. The fry can be raised on mass scale in nursery ponds. Selection of good stock and the culling of undesirable ones have to be meticulously followed.

5.1.7 DISEASES

Aquarium fishes are sensitive, delicate and easily susceptible to diseases. The majority of diseases that affect fish can be traced directly to their environment. Fish diseases are caused by the action of infectious agents and due to unsatisfactory environmental factors including water quality, in adequate diet and stress. The quality of water and significant alterations are likely to have lethal consequences. Sudden change in pH causes convulsions and death ultimately. So regular check of pH, and partial water changes are essential and they will eliminate these potential hazards to the fish health. D.O. and temperature of water are also important factors. Fish suffering from oxygen deficiency show signs of gasping at the surface of the water. So well balanced, regularly maintained and not overcrowded tank, under strictly hygienic conditions minimizes the risk of diseases. The potential for development of the ornamental fish industry is vast and this will be better realized if a more scientific approach could be adopted. Diseases can result in high mortalities, poor growth and other nutritional disturbances also arise. Losses of 60% to 90% of consignments have been commonly reported. For a rapidly developing industry such as the ornamental fish industry one has to adopt a modern integrated approach in order to ensure its greater success. Therefore a professional approach based on scientific criteria should be applied, as this is more critical for specialized field like fish disease.

When faced with severe outbreak of disease the fish concerned can be sent for examination to a laboratory. The current regulations concerning the dispatch of diseased fish to a laboratory should be ascertained, and it is often helpful if details such as their housing conditions, diet and symptoms are enclosed. A sample of water from their tanks is also often useful to laboratory. If possible it is preferable to arrange an appointment and call in person, because it is then possible to take the living specimens, which are affected, rather than corpses and these may be more useful to scientists for their research. Priority of remedies is a great help to the aquarist and should cope adequately with most common problems than can be treated. When using any treatment, however, the accompanying instructions on the pack should be followed closely, because some remedies, especially those containing copper are very likely to prove toxic if used in excess.

Poisoning and its prevention: The possibility of accidental poisoning should always be considered when there are a number of sudden mysterious deaths in a tank. Indeed, many of the forms of aerosol chemicals and sprays can prove toxic to fish. The air-borne particles settle on the water surface, if the tank is not covered. The threat is posed by chlorine and copper from newly installed pipes and has danger from cigarette smoke

Causes of diseases: Causes of diseases can be broadly classified as - biological, nutritional, genetic and stress related.

Biological factors: Biological factors are important in causing of diseases in ornamental fishes. Biological factors can be categorized as follows – viral, bacterial and fungal and those caused by parasites.

Viral infections: Various viruses affecting fish have been identified, and some of these are particularly significant for the fish farming. Spring varaemia of carp is a notifiable disease in this category, seen especially in the spring when water temperature is rising. It results in haemorrhages around the mouth and gills, and goldfish may also succumb to this virus. The swim bladder is affected in some cases, typically in younger fish. The *Rhabdovirus* concerned is often identified with Aeromonas bacteria while the virus conditions are grouped together as the carp-dropsy complex. There is no treatment for the virus. Lymphocystis is the best viral wart or pearl-like growths mainly on the fins and skin. No treatment is effective. It is recommended that wart be removed by minor surgery and the site be swabbed with iodine or acriflavine.

Bacterial infections: Bacterial infection is commonly seen in association with poor water quality as a secondary infection in parasitic diseases or after rough handling. Bacterial infections are generally caused by gram –ve group, particularly most dangerous is piscine tuberculosis, which was first recognized in 1897 and is still quite prevalent. The other common bacteria isolated are *Pseudomonas* and *Aeromonas* in fresh water fishes and *Vibrio* sps. in marine fishes. The general symptoms are - fish becomes darker in colour and does not show interest in feeding. Dermal haemorrhagic lesions occur along the lateral and ventral surface of the body, which may develop into ulcers. Internally, the spleen, liver and kidneys may be enlarged haemorrhagic or liquefied depending on the state of infection. The mode of swimming also gets changed depending upon the size of the fish and intensity of the infection. *Aeromonas* causes dropsy and sudden losses with fish going off their food. These bacteria are often isolated from cases in conjunction with virus. Infectious dropsy is seen especially in Goldfish. Fish infected with *Aeromonas* and *Pseudomonas* could be injected with tetracycline at 25mg/kg body weight or given 0.5mg/kg of food for 7 days or both at 50ppm overnight.

Fungal infections: Fungal spores can commonly be isolated from fish tanks but often cause disease only when the fish skin is damaged in some way. There are many different fungi grouped together in the family *Saprolegnlaceae*, but treatment of all fungal infections in similar irrespective of the specific causal organism. Malachitegreen as a 1% solution can be used.

Nutritional disorders: Nutritional deficiencies can occur if the fish is not fed the right kind of food, hence, the fish is deprived of certain essential nutritional requirements. On the other hand excessive feeding of vitamins and minerals can also cause different forms of disease conditions. Feeding schedule is also important. Highly active marine fish needs two times feeding for a day where as fresh water fish can be fed once a day.

Stress: Stress could be considered a major cause of fish disease that results in severe mortalities. Stress due to oxygen deficiency, excess of carbon dioxide, thermal stress lead to very complicated problems and death ultimately.

5.1.9. SUMMARY

Aquarium should be kept clear always and should be maintained cleanly. Only healthy fish and plants should be introduced into the tank. It should never be overcrowded with fish or plants, as it may lead to competition for food and obstruction to free movement of fishes. Children should not be allowed to handle the fishes. Fecal matter detritus should be removed from the tank at least once a week, as the accumulation pollutes the water. Water lost due to evaporation should be replaced once in a week and particularly during summer. Aquarium tank should be aerated properly so as to oxygenate the water and to keep the water circulating. Snails should never be introduced into the aquarium, as they may carry disease causing organisms, particularly the helminth diseases.

5.1.10. MODEL QUESTIONS

1. Write an essay on preparing the aquarium and introducing of fish.
2. Describe the Indian ornamental fishes.
3. Discuss the signs and control measures of ornamental fish diseases.
4. A. Feeding and general care of aquarium fish

   B. Breeding and general care

   C. Algae and their control.

5.1.11. REFERENCE BOOKS

1. Hand book of aqua farming ornamental fishes compiled by V.K. Dey ; MPEDA.
2. Hand book for aquarium fish hobbyists. K.V. Devaraj.
3. Fish diseases vol(1) Schaperclaus W (1991) Oxonian press pvt.Ltd.
4. Fish diseases vol(2) Schaperclaus W (1991) Oxonian press pvt.Ltd.
5. Text Book of Fish Diseases: Erwin Amlacher translated by D.A. Conroy and R.L. Herman.

Dr. P. V. Krishna

UNIT – V

LESSON - 5.2

FISH DISEASES : COMMON DISEASES IN CULTURE PONDS

5.2.1. Objectives
5.2.2. Introduction
5.2.3. Symptoms of sick/diseased fish
5.2.4. Causes of fish diseases
5.2.5. Types of diseases
5.2.5.1. Parasitic diseases
A. Viral diseases
B. Bacterial diseases
C. Fungal diseases
D. Protozoan diseases
E. Worm diseases (Helminthiasis)
a. Trematode parasitic diseases
I. Monogenetic trematode diseases
II. Digenetic trematode diseases
b. Cestode parasitic diseases
c. Nematode parasitic diseases
d. Acanthocephalan diseases
F. Annelidan parasitic diseases
G. Crustacean parasitic diseases
5.2.5.2. Non-parasitic disorders
A. Disorders by environmental factors
B. Nutritional disorders
5.2.6. Summary
5.2.7. Model questions
5.2.8. Reference Books

5.2.1. OBJECTIVES

The purpose of this lesson is to

* know the impact of diseases in culture ponds, the symptoms of sick fish and causes of diseases, and
* describe the symptoms and treatment of the common parasitic and non-parasitic diseases of fish in ponds with special emphasis on carp culture ponds.

5.2.2. INTRODUCTION

Fishes, like other aquatic animals, are prone to a variety of diseases. The important problem faced by a fish culturist in the diseases. Occurrence of disease in a pond leads to poor productivity or at times heavy fish mortality and loss to the farmer. Being cold-blooded vertebrates, they are subjected to changes in the environment. Generally fishes have very good resistance to disease as long as they are kept in well managed ponds. Inspite of the best efforts of the culturist, sometimes the fish become stressed, often producing pathological conditions. Environmental stress, dietary deficiencies, attack of pathogens and parasites affect the fish either directly or indirectly. Sometimes large scale fish mortality occurs due to epidemic infections. Therefore, the study of diseases is significant in the management of culture ponds.

5.2.3. SYMPTOMS OF SICK/DISEASED FISH

A sick fish may be easily identified by the following diagnostic features. 1) The sick fish is usually restless and often swims at the margins of the pond. 2) It is unable to maintain balance in water while swimming 3) It lies on one side either at the bottom or floating at the surface 4) Discoloration and presence of lesions or sores on the body. 5) The body appears more slimy 6) Gills become pale and secrete excess mucus 7) Disintegration of tail and fins occurs in some cases 8) Abnormal swelling of the belly or the belly may go thin 9) Lack of appetite and failure to feed 10) When taken out of water, the fish is not violent 11) when held by head, the trunk and tail of the fish hang down without offering any resistance 12) A sick fish is sluggish, and if held in hand under the water and turned to one side, the eye ball also turns following the turning of the body. In addition, there are specific symptoms to a particular disease.

5.2.4. CAUSES OF FISH DISEASES

Various factors are responsible for outbreak of diseases in fish. Over crowding of fish, poor planning of fish culture, contamination of water source, unhygienic conditions, deficiency in food, shortage of food and sudden changes in the physico-chemical condition of water such as the pH, temperature, dissolved oxygen and toxic gases, may favour the outbreak of diseases. Infection of pathogens and parasites causes diseases in fish. Almost all species of fish become infected with pathogenic bacteria, protozoans, fungi, helminth worms, and crustaceans. They may occur by direct contact or through vectors or contaminated food.

5.2.5. TYPES OF DISEASES

Diseases in fishes can be classified as parasitic and non-parasitic. The parasitic diseases include those caused by virus, bacteria, fungi, protozoans, worms, leeches and crustaceans, and the non-parasitic comprise disorders associated with nutritional deficiency and sudden changes in abiotic and biotic factors.

5.2.5.1. PARASITIC DISEASES

A. VIRAL DISEASES

i) VIRAL HAEMORRHAGIC SEPTICAEMIA (VHS):

It attacks only rainbow trout. The pathogenic virus of this disease is VHS virus (RNA virus). The symptoms are general anemia, discolouration of gills, swelling of eyes and belly, oedema of muscles, inflammation of intestine, skin sores, kidney swelling and protruded anus.

ii) INFECTIOUS HEMATOPOIETIC NECROSIS (IHN)

IHN disease outbreak was first observed in a hatchery of rainbow trout. Hematopoietic tissue of kidney and spleen undergo heavy necrosis in diseased fish. IHN virus is the causative agent. It is an RNA virus, which belongs to the rhabdo virus group. This disease occurs more in fry, fingerlings and occasionally in adults. The symptoms are black colouration of the body, pale gills, reddish fins, abdominal swelling and heavy mortality. The disease sign is a sudden rise in mortality of fish. Another characteristic of this disease is the passage of long, transparent fecal matter.

iii) INFECTIOUS PANCREATIC NECROSIS (IPN)

It is reported in young salmonid fishes. IPN virus is the causative agent. The diseased young fish exhibits spiral/whirling movements. The symptoms are darkening of body, protrusion of eyes and distention of abdomen. Poor maintenance, unfavourable environmental conditions and overstocking of fish are the causes for the outbreak of this disease.

iv) SPRING VIREMIA OF CARP (SVC) OR INFECTIOUS DROPSY OF CARPS

It is caused by *Rhabdovirus carpio*. Greatly distended abdomen, loss of balance, hemorrhage in skin, gills and dark colouration of body are the symptoms.

Swim bladder inflammation of carp (SBI), Pox disease in cyprinids (papilloma disease), papillomatosis (cauliflower disease) in eels, Lymphocystis disease, Sockeye salmon virus disease, Chinook salmon virus disease are other important viral diseases reported in fishes.

For these viral diseases there is no suitable treatment. The only precautionary measure is prevention of the disease.

In India, viral diseases are not prevalent in fish ponds.

B. BACTERIAL DISEASES

Bacterial diseases are common in fish culture ponds. Some of the diseases common in carp culture ponds are as follows.

i) BACTERIAL HEMORRHAGIC SEPTICEMIA (INFECTIOUS ABDOMINAL DROPSY OR ASCITES; MYO-ENTERO-HEPATIC SYNDROME)

It is an important epidemic disease inflicting heavy mortality in major carps. It is caused by the bacterium *Aeromonas liquefaciens* typus *ascitae* and/or *Pseudomonas punctata*. One year old carp are the major victims of the disease.

Symptoms: The disease symptoms can be differentiated as two types of symptoms like: a) typical or intestinal dropsy and b) the ulcerative dropsy. Intestinal dropsy is characterized by the accumulation of yellow coloured fluid in the abdominal cavity, protruded scales and exophthalmic condition. In case of ulcerative dropsy, appearance of ulcers on the skin and deformation of back bone is observed. Fish exhibit abnormal jumping. Sometimes both types of external symptoms appear in one fish.

Treatment: Removal of diseased fish, followed by draining, drying and disinfecting the pond by liming are preventive measures to control the disease. The disease can be controlled by using antibiotics like streptomycin or oxytetracyclin or chlortetracyclin administered in the supplementary feed at the rate of 7-10 g/100 kg of fish for 7 days, as oral treatment or 8-10 mg/litre for 1 hour for 2-3 days as bath treatment.

ii) TAIL AND FIN ROT

It occurs mostly in young fish and sometimes observed in adult fish. Sometimes, heavy mortalities are observed in carp nursery and rearing ponds. The causative bacteria are the species of *Pseudomonas* and *Aeromonas,* especially *P. flourescens, A. punctata, A. salmonicida, A. hydrophila* and *Haemophilus piscium*.

Symptoms: The disease is characterized by the putrefaction of the tail and other fins. The disease starts with slight cloudiness on the margins of fins. As the disease progresses, the fins are split at the edges and size of the fins is reduced to little more than a stump by the death and putrefaction of tissues. Frequently a secondary fungal infection occurs on the infected areas. In some cases exophthalmous or eye protrusion is seen. The affected fish can not swim and ultimately die.

Treatment: The disease can be controlled by using common salt at the rate of 110 ppm in the pond water or 1 minute bath treatment in 500 ppm copper sulphate solution or using oxytetracyclin or chlortetracyclin in the supplementary feed at the rate of 7-10 g/100 kg of fish for 7 days.

iii) EPIZOOTIC ULCERATIVE SYNDROME

It is the most dreaded disease in carp culture ponds. It causes large scale mortality of fish in ponds and natural water bodies. It first effects the murrels and other weed fishes in the culture ponds rather than the Indian major carps. The disease is caused by *Aeromonas hydrophila, A. punctata, Micrococcus* or *Preudomonas* spp.

Symptoms: The infection starts in the form of red spots, usually in the scale pockets in carps with rising scales and skin edema. In advanced stages, ulcers are formed with sloughing of scales and later the ulcers deepen and often with a black rim. Sometimes secondary fungal infections occur on the infected regions.

Treatment: Bath in copper sulphate solution (1:2000) for 1 minute for 3-4 days or oxytetracycline in the feed at the rate of 10 g/100 kg of fish for 7 to 10 days for early stage of infection. Fish in advanced stage of infection should be removed and destroyed and the pond water disinfected with 0.5 ppm solution of potassium permanganate.

Eye disease in catla, columnaris disease in many freshwater fish, vibriosis or pike pest in fresh and salt water fishes, Furunculosis in salmonids, bacterial gill disease in salmon and carp, Bacterial kidney disease in salmon and trouts, coldwater disease or peduncle disease in salmonids are the other bacterial diseases of economic importance in cultured fish.

C. FUNGAL DISEASES

i) SAPROLEGNIASIS

It is a very common water mold disease caused by *Saprolegnia parasitica*. Carps of all ages are easily susceptible to this fungal infection. It occurs as a secondary infection in fishes which sustain injuries or whose resistance has been weakened by other parasites and bad environmental conditions.

Symptoms: The disease is characterized by the growth of thin threads of dirty white or grey colour on fins, skin and eyes and resembles a tuft of cotton wool in severe cases. Other symptoms are ulceration of skin, haemorrhage, exposure of jaw bones, blindness, erosion of fins, inflammation of liver, intestine, etc.

Treatment: Pond treatments with common salt at the rate of 75 to 100 ppm or potassium permanganate at 1 ppm or copper sulphate at 0.5 to 10 ppm in 2-3 instalments at 3-4 days interval are used for controlling this disease.

ii) BRANCHIOMYCOSIS (GILL ROT)

It is caused by *Branchiomyces sanguinis*. This fungus blocks the veins in the gill filaments. This disease was found in carp, trout, gold fish, sticklebacks, pike and tench. Young fishes are more susceptible to the disease. Infection is epidemic during summer months especially in ponds where putrefying organic matter occurs in abundance.

Symptoms: The hyphae of fungus grow into the respiratory epithelium of the gills causing inflammation and necrosis. This leads to suffocation and ultimate death.

Treatment: Prevention of pollution, addition of quicklime (50-100 kg/ha), bath in 3-5% sodium chloride and 5 ppm potassium permanganate solution for 5-10 minutes. Pond treatments as given in saprolegniasis are also used for controlling this disease.

Other important fungal diseases are Ichthyosporidiasis in trouts, herrings, etc. Dermocystidium disease in common carp and Achlyasis in freshwater and marine fish.

D. PROTOZOAN DISEASES

i) ICHTHYOPHTHIRIASIS

It is also called 'Ich' or white spot disease. It is a common disease of major carps caused by the ciliate protozoan, *Ichthyophthirius multifilis* (Fig. 5-4A). The epidemic white spot disease outbreaks among weak fish and causes mass mortality.

Symptoms: Formation of white spots or cysts of about 1 mm size on skin, gills and fins which are really pockets of the parasites covered by epidermal cells of host fish.

Treatment: There is no effective treatment for Ich during the encysted stage. However, the parasites can be killed during the short free-swimming stage, when not embedded in the skin. Thus long term treatment is necessary for complete control of the disease. A 3% common salt solution or

1:5000 formalin solution for one hour a day for 7-10 days or 5 days bathing in 1:500,000 methylene blue solution is effective in killing all the parasites. The optimum temperature for ich is 21-24°C, hence the parasites can be killed by raising temperature of water from 29-31° C.

The other common ciliate protozoan parasitic diseases are Trichodiniasis caused by *Trichodina* spp (Fig. 5-4 B), Chilodonella disease caused by *Chilodonella cyprini*, and Epistylis disease caused by *Epistylis* spp.

ii) COSTIASIS

This disease is caused by a flagellate called *Costia necatrix* (Fig. 5-4 C). Costiasis is common in carps. This flagellate lives on the skin, fins and gills, destroys the epidermal cells and feeds on them. As a result, there is excessive secretion of mucus, hence also named as 'white cloud disease' or 'sliminess'.

Symptoms: Bluish mucus coating on the skin and irregular lesions.

Treatment: Dip in 3% sodium chloride solution or 1:4000 formalin solution or 1:500 acetic acid solution for 10 minutes. Pond treatments with 150 ppm sodium chloride or 55 ppm formalin or 0.5 ppm methylene blue or 1 ppm potassium permanganate or copper sulphate can also be used to kill the parasites.

Other common flagellate protozoan parasitic diseases are Octomitiasis caused by *Octomitus* spp., Trypanosomiasis by *Trypanoplasma* and *Cryptobia*.

iii) KNOT DISEASE

It is also called nodular disease or nodulosis. It is caused by myxosporidian parasites (sporozoans) like *Myxobolus* (Fig. 5-4 D) *Henneguya*, etc. It is the most common and dreaded disease occurring in culture ponds mostly in nursery ponds during winter months. The disease spreads especially when the fry or fingerlings are overcrowded and the water is not hygienic.

Symptoms: Presence of round or rice-shaped cysts in the form of little knots on the gills, fins, skin and internal organs. Cysts contain numerous spores. Infected fish shows sloughing of scales and stunted growth. During severe infections in gills, the fish gets suffocated, swim indolently, trying to catch its tail and dies.

Treatment: Not easily cured by chemical treatment. This disease is rare in well looked after ponds. Now-a-days pond treatment with common salt at 100-150 ppm was found to be effective. In case of failure, fish should be burnt or buried with lime.

The other important sporozoan parasitic diseases in fishes are Nodular coccidiosis in the intestine of carp, Enterococcidiosis in the intestine of carp, Whirling disease by a myxosporidian- *Myxosoma cerebralis* in trouts and salmons, boil disease by *Myxobolus pfefferi*, Microsporidiasis by *Nosema, Glugea* (Heart white spot disease) and *Plistophora* (Plistophorosis or myolytic sporozoiasis or Beko disease).

E. WORM DISEASES (HELMINTHIASIS)

Parasitic trematodes, cestodes, nematodes and acanthocephalans may be found in aquaculture animas, but seldom are they present in concentrations sufficient to cause significant problems except with monogenetic trematodes.

a) TREMATODE PARASITIC DISEASES

I) MONOGENETIC TREMATODE DISEASES

i) DACTYLOGYROSIS:

This disease is caused by the monogenetic trematode parasite, *Dactylogyrus* (Fig. 5-4 F). It is one of the most common ectoparasites of gills, hence, called 'gill fluke'. It has two pairs of eyes, two pairs of head organs and a ventral sucker at the anterior end and a 'haptor' at the posterior end with which it attaches to the host gill and feed on gill tissue. It causes large scale mortality of fish in carp culture ponds.

Symptoms: Gills are discoloured, the edges are thickened and secrets excess mucus. In severe infections the gill sheaths are attached together in a mass of mucus which leads to suffocation and death.

Treatment: Dip treatment in 5%common salt solution or in 1:5000 formalin solution for 5 minutes. Pond treatment with pesticides like Dichlorvos (Nuyan) at 0.1 ppm for 3 times at 4 days interval successfully controlled the dactylogyrosis.

ii) GYRODACTYLOSIS

The disease is caused by the monogenetic trematode parasite, *Gyrodactylus* (Fig. 5-4 E) which infects skin, fins and rarely the gills. It is commonly called 'Skin Fluke'. At the anterior end, *Gyrodactylus* has two conical projections having openings of glands producing sticky fluid, which helps in adhering to the skin or gills. Eyes are absent. At the posterior end 'haptor' is present. It causes heavy mortality of fish in carp culture ponds.

Symptoms: Fading body colour, loss of scales, excessive mucus and peeling of skin.
Treatment: It is same as that used for controlling Dactylogyrosis.

The other monogenetic trematode parasites like *Monocoeluim* and *Diplozoon* (twin worm) also parasitize the fish.

II) DIGENETIC TREMATODES

Diseases produced by trematode larvae (cercariae and metacercariae).

i) BLACK SPOT DISEASE OR DIPLOSTOMIASIS

It is caused by *Diplostomum* (Fig. 5-4 H). The metacercariae of the parasite give rise to the black spots on the body. In perch fish, metacercariae of *Neodiplostomum* cause black spot disease

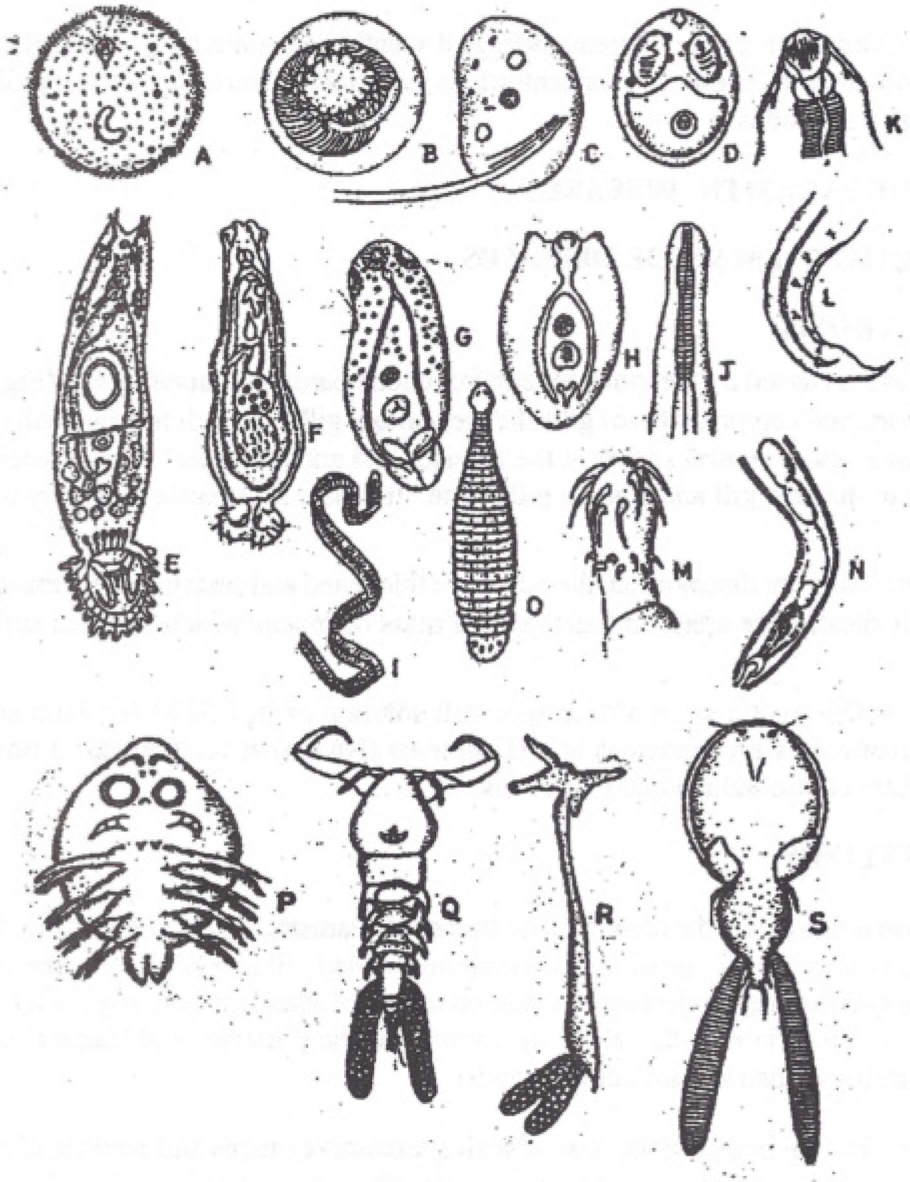

Fig. 5-4. (A-U) Common parasites of fish; (A-D) Protozoans; A) *Ichthyophthirius;* B) *Trichodina;* C) *Costia;* D) *Myxobolus;* (E-H) Trematodes; E) *Gyrodoctylus* F) *Dactylogyrus;* G) *Diplostomulum;* H) *Diplostomum;* I) Cestode, *Ligula;* **(J-L)** Nematodes; J) *Philometra;* (K& L) *Camallanus* (anterior and posterior regions); M & N) **Acanthocephalan,** *Zelanechinorhynchus* (Proboscis and posterior regions); O) *Hirudinean, Hemiclepsis.* P - S) **Crustacean** Parasites P) *Argulus Q) Ergasilus; R) Lernaea; S) Caligus.*

Symptoms: Small black spots or cysts all over the body. They cause virtually no effect on fish.

Treatment: Dip in 3:1,00,000 picric acid solution for one hour or Di-n-butyl tin oxide at the rate of 250 mg/kg fish in feed for 3 days.

ii) YELLOW GRUB DISEASE

It is found in freshwater fish. Yellow grubs are the metacercariae of the flat worm, *Clinostomum complanatum* and *C. marginalum*. Herons would be the final hosts. Eradication of snails would prevent the disease.

Symptoms: Small cream colored nodules or cysts containing metacercariae on the body, head and fins.

Other digenetic trematode parasitic diseases like Sanguinicola disease by *Sanguinicola* (blood flukes), grey pearl disease or Neascusiasis by *Neascus perlatus*, ink spot disease by *Isoparorchis* and worm cataract disease by *Proalaria (Hemistomum) spathaceum* are common in fishes.

b) CESTODE PARASITIC DISEASES

i) LIGULOSIS:

It is a condition caused by the cestode worm, *Ligula* (Fig. 5-4 I).

Symptoms: Fish becomes dull and sick, alimentary canal swollen and choked by cestode cysts or worms, gall bladder also affected.

Treatment: Dip in 3:1,00,000 picric acid solution for one hour or Di-n-butyl tin oxide at the rate of 25 mg/kg fish in feed for 3 days.

Other cestodes found parasitic in fishes are *Caryophyllaeus, Schistocephalus, Dibothriocephalus latus (Diphyllobothrium latum)* and *Triaenophrous*.

c) NEMATODE PARASITIC DISEASES

Nematode parasites such as *Heliconema proleptus, Camallanus* (Fig. 5-4 K&L), *Philometra* (Fig. 5-4 J), *Zeelanema*, etc. infect fish, usually the intestine. These worms cause obstruction in the passage of the alimentary canal. A dull or sickly behaviour is exhibited by the infected fish. A dip treatment in 3:1,00,000 picric acid solution for one hour or Di-n-butyl tin oxide at the rate of 250 mg/kg fish in feed for 3 days would be effective.

d) ACANTHOCEPHALAN DISEASES

The parasitic worms like *Acanthogyrus, Acanthocephalus, Pallisentis,* Zelanechinorhynchus (Fig. 5-4 M & N), etc. are known to infect fishes causing dull and sickly behaviour.

F) ANNELIDAN PARASITIC DISEASES

i) FISH LEECHES

Among annelids, the ectoparasitic fish leech, *Hemiclepsis* (Fig. 5-4 O) infests the carps and sucks the blood of the host causing irritation and abnormal movements. Other genera of leeches are *Piscicola salmositica, Acanthobdella* on salmonids, *Ottonia* and *Abranchus* on *Cottus scorpius*.

Treatment: Erection of bamboo or other wooden posts would help the fish to get rid of the ectoparasite by rubbing the body against the posts. A dip treatment in 1:1000 acetic acid and 5 ppm Gammexane would disinfect these ectoparasites.

G) CRUSTACEAN PARASITIC DISEASES

i) ARGULOSIS

Argulosis is caused by the fish parasite, *Argulus* (Fig. 5-4 P), which is commonly called *fish louse*. It is one of the most common and well-known fish parasites. Majority of fish farms are regularly infested with this parasite.

Argulus has a flattened shield like body which is greenish yellow or brownish in colour. It adheres to the fish by means of two large suckers on the ventral side. It has eight legs on the ventral side and two eyes on the dorsal anterior end. It perforates or pierces the skin of fish by means of a 'sting' or 'proboscis' and sucks the blood and tissue fluids of fish. Mouth is present behind the proboscis on a small rostrum. As the parasites are free-moving, they act as transmitters of bacterial and viral infections from fish to fish.

Symptoms: Affected fish rub their bodies against hard objects inorder to get rid of their ecto-parasites. The infected fish become very weak and emaciated. Stunted growth, thickening of mucus, loss of scales and red spots or wounds at the site of infection are also seen. Frequently, secondary bacterial and fungal infections occur on the wounds which lead to fish mortality.

Treatment: Pond treatment with organophosphate pesticides like Dichlorvos (Nuvan) at 0.1 ppm or Malathion (Cythion) at 0.2 ppm or Quinalphos (Ekalux) at 0.003 ppm is generally practiced for effective control of these parasites. Treatment should be given 3 or 4 times at weekly intervals. Since the eggs are resistant to the pesticide treatment, single treatment is insufficient for complete eradication.

ii) LERNAEASIS:

Lernaeasis is caused by *Lernaea* (Fig. 5-4 R), also known as *anchor worm*. It is one of the common fish ectoparasites. It causes severe damage to the young fish. Although *Lernaea* resembles a worm, it belongs to copepoda and is related to Cyclops. Only the females are parasitic and are modified into a minute rod-like external parasites (10-20 mm). On the infected fish, only the posterior portion of the parasite is visible as rod. The anterior portion is buried deep into the skin of fish by means of anchor-like appendages called cephalic horns. It feeds on blood and tissue fluids of fish. Symptoms and treatment are almost similar to those in argulosis.

iii) ERGASILOSIS

It is caused by *Ergasilus* (Fig. 5-4 Q) which is a gill parasite. Only female adults of ergasilids parasitize the gills. They are found on the gills of fish as bluish coloured bodies. They look like free-cyclopoid copepods, but one pair of antennae are modified into stout hooks for attachment. Mouth parts are adapted for biting.

Symptoms: The infected fish suffers from anemia, respiratory difficulties and poor growth. Further complications appear due to secondary bacterial and fungal infections.

Treatment: Same as that given for Argulosis.

Other crustacean parasites like *Achtheres, Sphyrion, Caligus* (Fig.5-4 S) and cirripedes cause considerable damage to fish.

5.2.5.2. NON-PARASITIC DISORDERS

A. DISORDERS BY ENVIRONMENTAL FACTORS

The environment, in which the fish live and grow, plays an important role in fish health. Any deterioration in the environmental qualities often creates **stress** to fish and favour the multiplication of pathogens. Sudden changes in abiotic and biotic factors often lead to mortality of fish in ponds. The common environmental hazards are as follows:

i) LACK OF OXYGEN / DEPLETION OF OXYGEN:

It is a common problem in ponds under semi-intensive culture system, especially during early hours, during algal die-offs and on cloudy and rainy days.

During dissolved oxygen depletion (<1 mg/l), fish swim at the surface to gasp the air and finally die due to asphyxiation. The fishes died due to asphyxiation can be recognized by their wide open mouths. Dissolved oxygen concentration can be improved by aerating the water or pumping the freshwater.

ii) GAS DUBBLE DISEASE OR AIR EMBOLISM

This disease has been observed mostly in spawn and fry. It is caused under the condition of super saturation of nitrogen or dissolved oxygen. When nitrogen of the water is higher than 125% saturation due to rapid pressure and temperature changes, this disease may result and fish seed die in large numbers. Besides nitrogen, supersaturated levels of oxygen (>350 per cent air saturation) also cause gas bubble disease in fishes.

Symptoms: Presence of bubbles beneath the skin, on fins, around eyes, in stomach and intestine or in blood capillaries. The affected fish swim at an angle of 45^0 with head pointing down.

Treatment: Transfer of fish to other ponds or water should be changed or well agitated to bring down the nitrogen saturation below 110%.

iii) DISORDERS CAUSED BY POLLUTANTS

Ammonia, detergents, phenols, chlorine, various pesticides are known to cause diseases and consequently mass mortality in fish. 1) Excessive ammonia (>1 mg/l) causes external bleeding and haemorrhage in internal organs. 2) Phenols, detergents and strong alkalies produce haemorrhage on skin, discolouration of gills, etc. 3) Chlorine (>4 mg/l) damages gills and bring about anemia and death after 8 hours in carps. 4) Arsenic salts, manganese chloride and acids cause blindness. 5) Elevated carbondioxide level produces nephrocalcinosis (ca deposits in ureters and swelling of kidney). 6) Hydrogen sulphide (> 0.6 mg/l) affects gills which become reddish-violet. It causes mass mortality in fish especially on very hot days during summer.

iv) ACIDOSIS

Majority of fish live in pH 7-8. Acidosis is caused when the pH of a pond suddenly goes down due to a fall in calcium salts or release of humic acids from soil. The fish exhibit fast swimming movements and often jump out of the water. Edges of gills become dark with excessive mucus secretion. Acidosis causes mass mortality. Addition of calcium carbonate cures acidosis by raising the pH to normality.

v) ALKALOSIS

Excessive dissolved oxygen in water is responsible for the formation of insoluble calcium carbonate from the soluble calcium bicarbonate. This is followed by formation of calcium oxide with the removal of carbondioxide. This phenomenon is known as alkalosis. This condition leads to corrosion of gill epithelium and fins. Alkalosis can be prevented by buffering the pond water by addition of soluble calcium salts.

vi) ALGAL TOXICOSIS

Algal bloom may appear in ponds due to accumulation of plenty of organic matter; or due to excessive chemical fertilization. Toxins released by blue–green algae like *Microcystis, Anabaena* and *Aphanizomenon* kill other phytoplankton and cause surfacing of fish stock. The affected fish show symptoms like convulsions leading to death.

B. NUTRITIONAL DISORDERS

These are caused by feeding the fish with inadequate and low quality feeds. The common among them in carp culture ponds are:

i) FATTY LIVER DEGENERATION OR LIPOIDOSIS

It is due to overfeeding the fish with more of fats and carbohydrates than proteins or due to feeding the fish with moist spoiled food.

Symptoms: Fish become lethargic, and appears darker than normal. All the internal organs are embedded in fat tissue. The liver becomes pale.

Treatment: Composition of feed should be changed and reduce the feeding rate for sometime.

ii) PIN-HEADS

This condition is due to starvation of inadequate feeding. The starved fish appears darker than normal with large head and very slender body. Hence, they are referred to as *'pin-heads'*.

Treatment: Feeding the fish with supplementary feeds containing 30-40% protein at the rate of 5% body weight fertilizing the pond for plankton production.

Several deficiency disorders due to vitamin deficiencies can be alleviated by providing vitamins in their food.

5.2.6. SUMMARY

1. Diseases are one of the major problems in culture ponds. Diseases are uncommon in well managed ponds. A sick fish can be identified from the healthy fish by its morphological and behavioural symptoms.

2. The factors responsible for causing diseases in fish are overcrowding, contamination of water source, unhygienic conditions, deficiency or shortage of food and sudden changes in physico-chemical parameters of water.

3. Diseases can be classified as parasitic and non-parasitic. The parasitic diseases are caused by virus, bacteria, fungi, protozoans, worms, leeches and crustacean parasites whereas the non-parasitic disorders are due to nutritional deficiencies and sudden changes in abiotic and biotic factors.

4. Viral diseases in fishes are prevalent in temperate regions. In tropical countries like India, viral diseases are not prevalent in fish ponds.

5. Bacterial diseases are common in fish ponds of India. Some of the common bacterial diseases in carp culture ponds are bacterial haemorrhagic septicemia, Tail and fin rot, epizootic ulcerative syndrome and columnaris disease.

6. The common fungal diseases are saprolegniasis and branchiomycosis. Protozoan diseases due to parasitic ciliates, flagellates and sporozoans are common in fish ponds.

7. Helminthic worm diseases due to parasitic trematodes, cestodes, nematodes and acanthocephalans are common but not problematic in fish ponds except monogenetic trematodes. The digenetic trematodes and other require another host for completing their life cycle. Hence, they are uncommon in carp culture ponds.

8. Monogenetic trematode parasites like *Gyrodactylus* and *Dactylogyrus* cause severe infections which sometimes lead to heavy mortalities in carp culture ponds.

9. Among annelids, fish leeches belonging to the family Piscicolidae are parasitic on fishes. They are also rare in culture ponds.

10. Among crustacean parasites common in carp culture ponds, *Argulus* and *Lernaea* cause heavy damage to fish in carp culture ponds.

11. The non-parasitic disorders may be due to environmental hazards like depletion of oxygen, gas bubble disease, pollution, acidosis or alkalosis, algal toxicosis, etc. or due to nutritional deficiencies.

5.2.7. MODEL QUESTIONS

1. Write an essay on the common diseases of carps and their control in fish ponds.
2. Give an account of the parasitic diseases in fish ponds.
3. Write notes on

a. Bacterial diseases in fish ponds.

b. Crustacean parasitic discases in carp culture ponds.

c. Common nutritional disorders of carp in culture ponds.

d. Gas bubble disease.

5.2.8. REFERENCE BOOKS

Conroy, D.A. and Herman, R.L. 1968. *Text Book of Fish Diseases*. TFH Great Britain Ltd., England. Indian Reprint, 1997, Narendra Publishing House, Delhi.

Jhingran, V.G., 1991. *Fish and Fisheries of India*. Hindustan Publishing corporation (India) Delhi.

Reichenbach Klinke, H.H. 1965 *Fish Pathology*. TFH (Great Britain Ltd.) England.

a. Natural Gynogenesis : Gynogenesis occurs naturally in some species of the family poecilidae e.g., Poecilia Formosa and Cyprinidae e.g., Carassius auratus gibelio. 10 min and respectively, 4 min after activation.

Lokra, W.S. Chromosome engineering in Aquaculture. In : Gnetics amd Biotechnological tools in Aquaculture and fisheries. Manual CAS Training Programme, Dec. 2-31, 1998. Fish Genetics and Biotechnology Division, Central Institute of Freshwater Aquaculture.

Gupta, S.D. *Cryopreservation of carp milt. In Training Manual on Biotechnology in Aquaculture,* 24 March -9, April 1992. Central Institute of Freshwater Aquaculture, Bhuvaneswar, India.

Lakra, W.S. Chromosome engineering in Aquaculture. In : Genetics and Biotechnology tools in Aquaculture and Fisheries. Manual CAS Training Programme, Dec. 2-31, 1998. Fish Genetics and Biotechnology Division, Central Institute of Freshwater Aquaculture, Bhubaneswar, India.

Dr. P. Padmavathi

UNIT – V

LESSON - 5.3

IMPROVEMENT OF FISH STOCKS: HYBRIDIZATION OF FISH - INDIAN STUDIES

5.3.1. Objectives
5.3.2. Introduction
5.3.3. Hybridization of fish – Indian Studies
  A. Objectives of fish hybridization
  B. Traits of certain hybrids
    a. Among Indian carps
      i) Interspecific hybrids
      ii) Intergeneric hybrids
    b. Among Indian and exotic carps
    c. Among exotic carps
    d. Among Indian catfishes
    e. Among Indian and exotic catfishes
    f. Monosex hybrids
  C. Negative/Genetic impact of hybridization
5.3.4. Summary
5.3.5. Glossary
5.3.6. Model Questions
5.3.7. Reference Books

5.3.1. OBJECTIVES

The purpose of this lesson is to

* know the importance and ways of improvement of fish stocks, and
* study the fish hybridization as a rapid route to genetic improvement of fish stocks with special reference to Indian studies.

5.3.2. INTRODUCTION

The need for enhancing food production to cope with the ever increasing human population has assumed vital importance all over the world. In this context, aquaculture opens up a new avenue for protein production. Among different aquatic organisms, fish constitute the most common, cheap and highly proteinaceous food. In India, the aquaculture technologies developed during yester decades have led to the progressive increase in fish production from an average level of 600 kg/ha/year to 10-12 t/ha/year. These technologies are mainly based on judicious manipulation of species ratios and management practices on sound scientific lines. However, as every technology has its own limitations, any further increase in the production through manipulations and management practices may not be economically viable. Moreover, intense carp culture system involving the use of heavy inputs of feeds and fertilizers may cause imbalance in pond environment. In this situation, the only promising way to improve production is by genetic improvement of the fish stocks. The genetically improved animals are able to respond to the improved management techniques so that full benefits of investments can be obtained.

The use of genetically selected strains and hybrids in enhancing the production levels has contributed very substantially to modern agriculture and animal husbandry. But aquaculture has benefited very little from efficient breeding and selection programmes. Application of genetics in aquaculture is extremely limited due to the difficult nature of the aquatic medium, greater genetic and environmental variability in aquaculture species, the delays in the development of suitable techniques for controlled reproduction and the paucity of genetic expertise among aquaculturists. Genetic improvements usually require long-term experimentation with a large number of individuals and generations, and so considerable time may elapse before useful results become available.

In India, after the success of induced breeding of Indian major carps, genetic improvement work with regard to these carps has been initiated starting from simple interspecific and intergeneric hybridization, followed by genome manipulations and selection work. One of the potential and conventional ways of improving the genetic worth of aquaculture species is through selection and hybridization. These are the classic breeding techniques for improvement of qualitative traits in fishes. Thus for the production of genetically superior progeny, selection and cross-breeding programmes are necessary.

Selective breeding is a classical approach to improve the fish stocks. Genetic gain obtained by this process is cumulative, which can be improved over generations by keeping the inbreeding coefficient low. In India, selective breeding work with the rohu over the years has demonstrated growth increments of about 15% over the parental stock.

5.3.3. HYBRIDIZATION OF FISH – INDIAN STUDIES:

Hybridization is a rapid route to genetic improvement. Hybridization is one of the methods employed for combining desirable qualities of selected fishes, which would inter-breed, and also raise strains superior to those to which the parents belong. Fish hybrids generally tend to be intermediate in taxonomic characters pertaining to the parents but may show desirable qualities from the economic point of view such as hardiness, faster growth rate and greater resistance to diseases. However, most of the fish hybrids which have been produced in the last 100 years are less fit than the parents. It is only in a small group of species where the hybrids have proved to be of significant practical value. These include hybrids of cyprinids, bass, salmonids, tilapias and sturgeons.

Hybridization is an indirect method of incorporating and combining the useful characteristics from the parent species belongs to two different species of the same genus (inter-specific) or two different genera (inter-generic) or else two strains of the same species (intra-specific). Hybridization is rather an indirect method of genome modification or manipulation where the genome of the off-spring is altered by combining the haploid genome of the two different parent species.

Hybridization is a good breeding programme only when hybrids show heterosis or hybrid vigour. Heterosis has been obtained in intra-specific and inter-specific crosses as well as in some inter-generic crosses of domestic stocks of common carp and tilapia. It has been observed that intra-specific hybridization may be more useful than the inter-specific and inter-generic. Many workers have obtained very encouraging results in intra-specific hybridization experiments. While hybrids are normally produced through artificial means by fertilizing the female gametes of one parent with the male gametes of another, natural hybrids are also available as a result of inadvertent cross fertilization in nature.

A. OBJECTIVES OF FISH HYBRIDIZATION

The objectives behind carp, catfish and tilapia hybridization are enlisted as follows:

1. To improve the growth rates
2. To increase the meat: bone ratio
3. To improve meat quality
4. To improve food conversion efficiency
5. To improve resistance to unfavourable environmental conditions
6. To increase salinity/freshwater tolerance
7. To increase heat/cold tolerance
8. To produce desired appearances/body colour
9. To enlarge the feeding spectrum
10. To reduce predatory/cannibalistic tendency
11. To delay/enhance maturity
12. To increase fecundity
13. To produce sterile fish
14. To produce monosex progeny
15. To increase resistance to diseases

Considerable work on hybridization has been carried out in India since the early attempts of Chaudhuri (1959). This subject has been reviewed by many workers. The development of induced breeding techniques by hormone injections has widened the possibilities of fish hybridization. In India, hybridization work was carried out mainly on Indian and exotic carps and catfishes.

B. TRAITS OF CERTAIN HYBRIDS

a. AMONG INDIAN CARPS

i) Interspecific hybrids

In India, Chaudhuri (1959) produced five interspecific hybrids of the genus *Labeo*.

Male parent species	Female parent species	Hybrid
Labeo rohita	*Labeo calbasu*	rohu – calbasu
L. calbasu	*L. rohita*	calbasu – rohu
L. bata	*L. rohita*	bata – rohu
L. bata	*L. calbasu*	bata – calbasu
L. calbasu	*L. gonius*	calbasu – gonius

Among these interspecific crosses, only the reciprocal crosses between *Labeo rohita* and *Labeo calbasu* have been reported to possess some useful traits. These hybrids were highly viable with a high percentage of fertilization (94%) with normal development of the zygotes. The growth rate was better than the slow growing parent, i.e. the calbasu. These hybrids were found fertile and attained maturity in two years. The matured hybrids could be bred through hypophysation and F_2 generation could be produced which also exhibited higher percentage of fertilization. Other interspecific hybrids exhibited poor hatching and low survival rates.

ii) Intergeneric hybrids

The three genera comprising the six species of major and medium-sized cultivable carps were crossed to produce the following successful intergeneric hybrids.

Male parent species	Female parent species	Hybrid
Catla catla	*Labeo rohita*	Catla – rohu
C. catla	*L. calbasu*	Catla – calbasu
C. catla	*Cirrhinus mrigala*	Catla – mrigal
L. rohita	*C. mrigala*	Rohu - mrigal
L. rohita	*Catla catla*	Rohu – catla
C. mrigala	*L. rohita*	Mrigal – rohu
C. mrigala	*L. calbasu*	Mrigal – calbasu
C. reba	*L. rohita*	Reba – rohu
C. reba	*L. calbasu*	Reba – calbasu
Labeo fimbriatus	*Catla catla*	Fimbriatus – catla

Of these hybrids, catla-rohu, rohu-catla and catla-mrigal exhibited some useful traits. Of all the hybrids catla-rohu is the most promising hybrid which tends to combine the quick growth of catla and small head of rohu. Comparative growth of both the hybrids, *viz.*, catla-rohu and rohu-catla indicated that the former grows slightly faster than rohu-catla. Rohu-catla when compared to equal-sized parent contains more quantity of flesh than catla (44%) and rohu (48%). The majority of the

hybrids showed intermediate characters as compared to those of the parents. The hybrid rohu-mrigal had relatively small head, deeper body and slender caudal peduncle.

These hybrids with intermediate traits achieved only partial, not full, heterosis and hence did not meet the desired objective. For example, the rohu-catla hybrid had smaller head than catla but larger than rohu and similarly the body deeper than rohu but not as deep as that of catla. It grows faster than rohu but not as fast as catla. This could be easily explained by the inheritance of only 50% of the genomic input or haploid genome of the parent species, thus preventing/hampering the full expression of the parental trait.

The mrigal-calbasu hybrid was observed to mature fully in 2-3 years. One 8 year old female mrigal-calbasu hybrid was induced bred by pituitary injection, and the stripped eggs were fertilized by the milt from males of catla, calbasu and mrigal and the following hybrids were produced.

Male parent species	Female parent species	Hybrid
Catla catla	*Mrigal – calbasu*	*Catla – mrigal – calbasu*
Labeo calbasu	Mrigal – calbasu	Calbasu – mrigal – calbasu
Cirrhinus mrigal	Mrigal – calbasu	Mrigal – mrigal – calbasu

b. AMONG INDIAN AND EXOTIC CARPS

Intergeneric crosses between the Indian major carps and the exotic common carp were made with a view to incorporate early maturity and the pond breeding habit of common carp in the hybrids. However, hybrid crosses between species with larger or unequal diploid number of chromosomes such as between Indian carps (2n=50) and common carp, *Cyprinus carpio* var. *communis* (2n=104) may result in **sterile hybrids** with an aneuploid state of genome. Sterile hybrids may be useful for stocking inorder to control the population density in a pond. The potential advantages of sterile hybrids are population control and improved growth.

The earliest attempts at producing hybrids by crossing *L. rohita* and *L. fimbriatus* with common carp were only partially successful. Though the growth was satisfactory, the hybrids were **sterile** with poor rate of survival so that only a few remained to attain the adult size. Intergeneric hybrid between catla or rohu and big head/grass carp/silver carp did not survive beyond two weeks.

The intergeneric hybrids between common carp and the three Indian major carps showed intermediate characters and are viable, the most viable being common carp – rohu. The hybrids are elongated but had a characteristic dorsally convex body with a slight hump. The mouth is terminal and smaller than common carp. The hybrids exhibited faster growth rate but sterile. These sterile hybrids are very useful in fish culture management where common carp tends to overpopulate due to their prolific breeding in captivity. Moreover, common carp always escape fishing nets during harvesting. Of great practical value was the trait that, unlike the mother parent, they did not burrow at the base of the pond dikes and thus did not damage the embankments and easy to harvest. Being sterile, these were recommended for stocking the reservoirs where the common carp upsets the balanced population. Thus their superior growth, higher flesh content and high catching efficiency and the ease with which these sterile hybrids can be propagated, enhance the possibility of including them in fish culture in place of common carp.

c. AMONG EXOTIC CARPS

A number of attempts were made to produce hybrids of the exotic carps during the sixties. Among these could be listed grass carp x bighead, silver carp x bighead, silver carp x grass carp, common carp x silver carp and common carp x grass carp. However, none of these survived for long to enable further studies.

d. AMONG INDIAN CATFISHES

Sunderaraj and Goswami (1969) obtained reciprocal crosses between the males and females of *Heteropneustes fossilis* (Singhi) and *Clarias batrachus* (magur). They also obtained viable fry by fertilizing *H. fossilis* eggs with milt from *Mystus vittatus* but the reciprocal cross was not successful. However, none of these hybrids are available for aquaculture.

Padhi et al. (1995) have made some interesting observations on the reciprocal crosses between *H. fossilis* and *C. batrachus*. Low survival at hatching (8-11%) and still lower at 5 day old stage (0.8 – 0.9%) was observed. The hybrids possessed a long dorsal fin like that of *C. batrachus* and the accessory respiratory organ resembled the paternal parent. The diploid chromosome number of the hybrids (2n=53) was the average of the two parental species (Singhi, 2n=56; magur, 2n=50). It needs to be noted that despite their morphological and anatomical divergence, reproductive and genomic compatibility exists. The high rate of fertilization (60-70%) and survival of some specimens for more than a year is ample proof of the same.

e. AMONG INDIAN AND EXOTIC CATFISHES

Commercial production of viable hybrid between *Clarias batrachus* (margur) and *C. gariepinus* is practiced in Bangladesh and the fry exported to India for aquaculture in the bordering states as also in Bihar and Andhra Pradesh. A comparison of this hybrid with its reciprocal and their control siblings indicated significantly better performance of the former in all respects from hatching to viability of the larvae, growth and survival. In reciprocal crosses, survivors were mostly deformed and abnormal which later suffered heavy mortality. The hybrid resembles the indigenous magur till it attains a size of 200-250 g when it is harvested as the consumer is not able to distinguish between the hybrid and its parental species at this stage. It is considered to be non-predaceous, good looking and as tasty as *C. batrachus*. However, connoisseurs differ in their evaluation but millions of fry are imported into India and a lucrative trade exists.

f. MONOSEX HYBRIDS

Of late, interest in the production of monosex hybrids through interspecific crossing has increased, for improving the culture of the species of tilapia, that reproduce rapidly and over-populate ponds. Selected species were crossed for the purpose of obtaining all-male progeny. The progeny consisted of a high percentage (98-100%) of male off-spring. However, commercial production of all male hybrids has been difficult to maintain over a long period of time due to contamination of pure brood stock lines. There has also been considerable interest in breeding mutant forms of tilapia such as the red tilapia which has better consumer acceptance.

C. NEGATIVE/GENETIC IMPACT OF HYBRIDIZATION

Adaptability of any hybrid to the environment is determined by genetic introgression i.e. flow of genes from one species gene pool to another species. If introgression is <0.1%, it may help in increasing capability of adaptation against the natural selection. A large amount of gene flow may disrupt the adoptive gene complexes, which have evolved overnight to permit a species to effectively use its particular environmental niche. So while releasing any hybrid to the nature care should be taken to evaluate it properly. Due to indiscriminate hybridization, gene pool of some species are affected and in some the population size is reduced. Reduction of genetic diversity can also occur because of indiscriminate intraspecific hybridization. Contamination of the gene pool of our prized food fishes with genomic plasticity is the greatest danger that faces their natural populations.

5.3.4. SUMMARY

1. To meet the food demand of the increasing human population, there is a need to improve the production of fish. Of the several aquaculture technologies used in the improvement of production, genetic improvement of the stocks is found to be the only promising way.

2. The genetic improvement of fish species always requires the most effective methods of selection and hybridization. These methods were successfully carried out by the development of induced breeding techniques by hormone injections.

3. Hybridization is a rapid route to genetic improvement. It is one of the methods employed for combining desirable qualities of selected fishes, which would inter-breed, and also raise strains superior to those to which the parents belong. Hybrids are intermediate in taxonomic characters of the parents and show desirable qualities like hardiness, fast growth and disease resistance.

4. Hybridization may be intra-specific or inter-specific or inter-generic. Heterosis has been obtained in intra-specific and inter-specific crosses as well as in some inter-generic crosses of domestic stocks.

5. The main objectives of fish hybridization are enhanced growth rate, better food conversion efficiency, increased disease resistance or survival, and carcass (meat) quality.

6. In India, hybridization work was carried out mainly on Indian and exotic carps and catfishes.

7. Among Indian carps, five interspecific hybrids of the genus *Labeo* were produced. Among these hybrids only the reciprocal crosses between *L. rohita* and *L. calbasu* showed some useful traits like fast growth rate, high survival and high percentage of fertilization at F_1 and F_2 generations. With

regard to intergeneric hybridization, as many as ten hybrids have been produced among members of the three genera *viz., Catla, Labeo* and *Cirrhinus* involving five species. Of all the intergeneric hybrids, catla-rohu is the most promising hybrid with regard to fast growth, more flesh content and small head. These hybrids acquire only intermediate traits or partial heterosis.

8. Intergeneric crosses between Indian and exotic carps resulted in sterile hybrids. Of all these hybrids, common carp-rohu is the most viable. The potential advantages of sterile hybrids are population control and improved growth.

9. Among exotic carps (big head, silver carp and grass carp), none of the hybrid survived for long to enable further studies.

10. Among Indian catfishes, reciprocal crosses between the males and females of *Heteropneustes fossilis* and *Clarias batrachus* produced successful hybrids. Viable hybrids were also obtained by crossing female *H. fossilis* and male *M. vittatus*.

11. Among Indian and exotic catfishes, commercial production of viable hybrids was practiced with *Clarias batrachus* and *C. gariepinus*. The hybrid resembles *C. batrachus* till it attains a size of about 250 g.

12. For improving the culture of tilapia, the production of monosex hybrids through interspecific crossing attained a special significance. Tilapia is a prolific breeder that reproduces rapidly and overpopulate ponds. Production of all-male progeny for intensive culture of tilapia assumed importance in recent years.

13. Contamination of the gene pool of our prized food fishes with genomic plasticity is the greatest danger that faces their natural populations.

5.3.5. GLOSSARY

Aneuploid: Having more or less than an integral multiple of the haploid number of chromosomes; therefore genetically unbalanced.

Gene flow: Movement of genes, as a result of mating and gene exchange, within populations.

Genome: The set of all different chromosomes found in each nucleus of a given species. A haploid nucleus has one genome.

Hybrid: Plant or animal resulting from a cross between parents that are genetically unlike. Hybrid may be fertile or sterile. The more distant the genetic relationship between parents the greater is the probability that hybrids will be sterile; sterility is due to failures in pairing of chromosome in meiosis.

Heterosis (Hybrid vigour): Increased vigour of growth, fertility, etc., in a cross between two genetically different lines, as compared with growth, etc. in either of the parentallines; associated with increased heterozygosity.

Inbreeding: Reproduction by the mating of closely related individuals as opposed to outbreeding by the mating of less related individuals.

Introgression: Infiltration of genes of one species into genotype of another. when two species come into contact under conditions favouring one or the other, if hybrids are produced they tend to backcross with the favoured species. This process, continually repeated, results in a population of individuals most of which resemble the predominant parent but which possess also some characters of the another parent.

Siblings (Sibs): Brother and/or sisters; offspring of same male parent and same female parent.

Trait: Characteristic feature of an individual.

5.3.6. MODEL QUESTIONS

1. Given an account of the improvement of fish stocks through hybridization with reference to Indian studies.
2. Write notes on
    a. Hybridization among Indian carps
    b. Objectives of fish hybridization
    c. Monosex hybrids
    d. Intergeneric hybrids of Indian and exotic carps.

5.3.7. REFERENCE BOOKS

Jhingran, V.G. 1991. *Fish and Fisheries of India.* Hindustan Publishing Corporation (India) Delhi.

Sinha, VRP and H.C. Srivastava. 1995, *Aquaculture Productivity.*

James H. Thomas. 1992. *Aquaculture Research Needs for 2000 AD.* Oxford and 1BH Publishing Co. Pvt. Ltd., New Delhi.

Reddy, P.V.G.K., Kanta Das Mohapatra, H.K. Barman, R.K. Jana and J.N. Saha, 1997. *Genetic Improvement Methods in Asiatic carps.* Manual series (4): 42 pp. Central Instituteof Freshwater Aquaculture, Bhubaneswar, India.

Tripathi, S.D. 1998. *Hybridization of fishes. In: Genetics and Biotechnological tools in Aquaculture and Fisheries.* Manual, CAS training programme, 1998. Central Institute of Freshwater Aquaculture, Bhubaneswar, India.

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UNIT – V

LESSON - 5.4

BIOTECHNOLOGICAL APPROACHES: GYNOGENESIS, ANDROGENESIS, POLYPLOIDY AND CRYOPRESERVATION OF MILT OF FISH

5.4.1. Objectives
5.4.2. Introduction
5.4.3. Genome manipulations
- **A. Gynogenesis**
- **a. Natural gynogenesis**
- **b. Induced gynogenesis**
- **B. Androgenesis**
  - **a. Natural androgenesis**
  - **b. Induced androgenesis**
- **C. Polyploidy**
  - **a. Natural polyploidy**
  - **b. Induced polyploidy**

5.4.4. Cryopreservation of milt of fish
- **A. General considerations for preservation of fish sperms**
  - **a. Effects of cooling and freezing on cellular systems**
  - **b. Effect of low temperature on cell membranes**
  - **c. Morphology of fish spermatozoa**
  - **d. Motility of sperm cells**
- ***B. Preservation of sperm***
  - **a. Short term preservation**
  - **b. Cryopreservation of sperms (Long term preservation)**

5.4.5. Summary
5.4.6. Glossary
5.4.7. Model Questions
5.4.8. Reference Books

5.4.1. OBJECTIVES

The purpose of this lesson is to

* know the importance of biotechnological applications for the betterment of aquaculture industry and the techniques of genome manipulations including gynogenesis, androgenesis and polypoidy and

* know the importance and technique of cryopreservation of spermatozoa of fish.

5.4.2. INTRODUCTION

Biotechnology is a general term that refers to any endeavour using applied biology as the basis of technology. Any modifications in the natural process of living organisms can be termed as bioengineering and the technology that is developed to bring about such modifications is biotechnology. Biotechnology came into prominence due to the applications of the knowledge and techniques of molecular biology. The United States Office of Technology Assessment defines biotechnology as "Any technique that uses living organisms or substances from those organisms, to make or modify a product, to improve plants or animals or to develop microorganisms for specific uses". Thus biotechnology involves many technical processes employing biological organisms for specific purposes towards human welfare. The current progress in biotechnology is due to:

1. *In vitro* culture of plant and animal cells
2. Developments in immunology
3. Characterization of genetic materials (DNA)
4. Capabilities to move and express genes among living organisms using the recombinant DNA techniques.

The last two areas which are popularly known as "Genomics" and "Genetic Engineering" have revolutionized biology in recent years.

Aquaculture is a broad-ranging business that reaches into all our lives, either as food, components of food, medicines, etc. As the oceanic resources dwindle due to over-fishing and environmental degradation, the food produced through aquaculture appears to be the alternative source of dietary protein. Aquaculture, like other agricultural practices, is prone to a variety of problems. Many of them can be solved by widespread application of biotechnology.

Aquaculture industry demands species with high food-conversion efficiency, fast growth, greater disease resistance and good stress tolerance. The conventional methods to achieve the above factors are, supply of high energy feed and the administration of growth hormones and other chemicals, but the former is expensive and the latter is hazardous to human health. These problems can be mitigated by employing efficient methods of genetics, and chromosomal and genetic engineering in the multibillion industry of aquaculture. The methods can be used to alter the genetic material in the cells of aquaculture species either at chromosomal or at gene level for producing sterile fish, fish of selected sex, triploids and transgenic fish. These manipulations are easily done in fish and shellfish as they produce large number of eggs with external fertilization.

5.4.3. GENOME MANIPULATIONS (Chromosal engineering)

Genome manipulation or genetic engineering, whether it is through chromosomal engineering or gene transfer techniques, is aimed to provide an individual with extra ability for better performance in its environment. Genome refers to the chromosome complexity of a given individual. Manipulation of the genome is directly concerned with the chromosomes. Genome manipulations or chromosome set manipulations are brought about through rather tampering with the original genomic structure of an individual in a systematic manner but abide by certain biological laws. This process usually results in the alteration of the chromosome sets, may be addition of extra set (s) to the existing diploid complement (triploid/tetraploid) or replacement with a duplicate set (gynogenesis/androgenesis) of one and the same individual. Chromosomal manipulation for inducing polyploidy, gynogenesis (all maternal inheritance) and androgenesis (all paternal inheritance) has been studied with a view to controlling sex, as well as for rapid inbreeding. Manipulation becomes feasible during the nuclear cycles of cell division, and since fertilization in fish is external, artificial means can be employed either to the gamete before fertilization, or to the fertilized egg at any period during the formation of the zygote.

A. GYNOGENESIS

Gynogenesis is the maternal inheritance in which the offsprings derive the chromosomes from their mother. It is a specialized form of parthenogenesis which involves production of diploid individual with both chromosome set from female parent. Here the normal eggs are fertilized with genetically inactivated sperm. The resulting zygotes are haploid. Unless diploidly is restored, the haploid embryos die during the development or soon after hatching. In natural gynogenesis restoration of diploidy may occur spontaneously whereas in induced gynogenesis, diploidy is restored by suppressing the second meiotic division, in other words, preventing the extrusion of the second polar body of the eggs (Fig. 5-5). This is done by giving thermal/pressure shock treatments including radiation shocks (UV or gamma rays) or chemical treatment of the eggs at an appropriate time after fertilization.

a. Natural Gynogenesis: Gynogenesis occurs naturally in some species of the family Poecilidae e.g., *Poecilia formosa* and Cyprinidae e.g., *Carassius auratus gibelio*. Natural gynogenesis has also been reported among the members of the family pleuronectidae.

b. Induced Gynogenesis: Gynogenesis can be artificially induced by inactivating (denaturing) the genetic material (DNA) of the penetrating sperm through irradiation by exposing either to UV or Gamma rays, and allowed this inactive sperm to fertilize the egg. However, such genetically inactivated sperm cannot fertilize the eggs but only activate them to develop into haploid embryos which ultimately die during the development or soon after hatching, unless diploidy is restored. Diploidy is restored by giving either thermal (cold/heat) or hydrostatic pressure shock treatments. Gynogenesis could be successfully induced in Indian major carps. The intensity of cold and heat shocks was 12^{0}C and 39^{0}C with a duration of 10 min and 1 min respectively, 4 min after activation.

Types of artificial gynogenesis: The gynogenesis is of two types depending on the mode of restoration of diploidy. If the diploidy is restored by preventing the extrusion of 2nd polar body (i.e. retaining the 2nd polar body), it results in meiotic gynogenesis. The mitotic gynogenesis is achieved by blocking the first cleavage. The degree of homozygosity in meiotic and mitotic gynogenes is supposed to be 50% and 100% respectively.

Meiotic gynogenesis can be induced by administering early shock treatment to the activated egg (by UV-irradiated sperm) leading to the retention of the second polar body. A diagrammatic illustration of the process is given in Fig. 5-5. The gynogens resulting from meiotic gynogenesis may

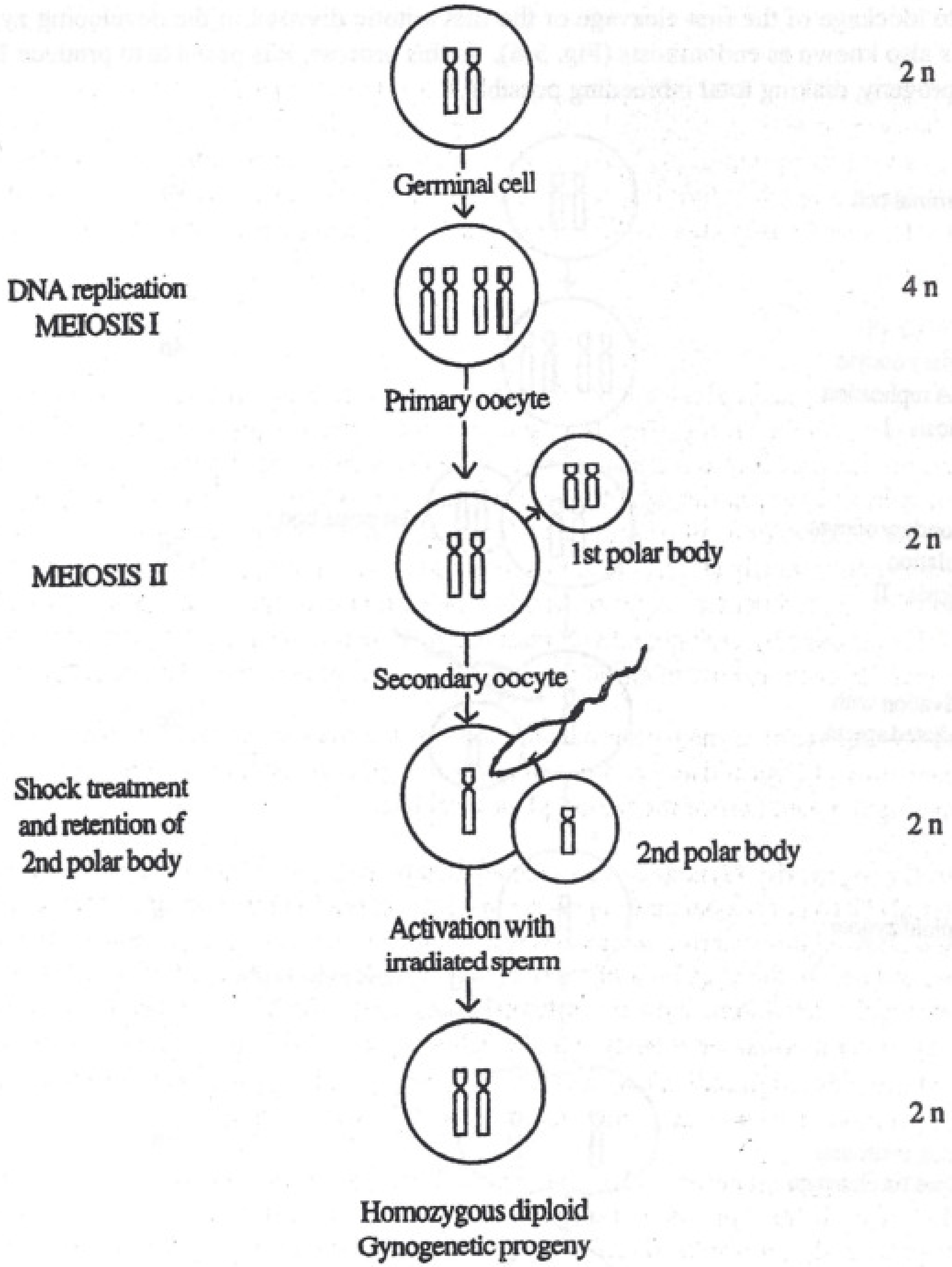


Fig. 5-5 *Induced gynogenesis by the retention of the 2nd polar body*

be heterozygous or homozygous. Complete homozygosity may be achieved through 4 to 5 generations of meiotic gynogens.

Mitotic gynogenesis can be induced by administering late shock treatment to the activated eggs leading to blockage of the first cleavage or the first mitotic division in the developing zygote. This process is also known as endomitosis (Fig. 5-6). In this process, it is possible to produce 100% homozygous progeny, making total inbreeding possible.

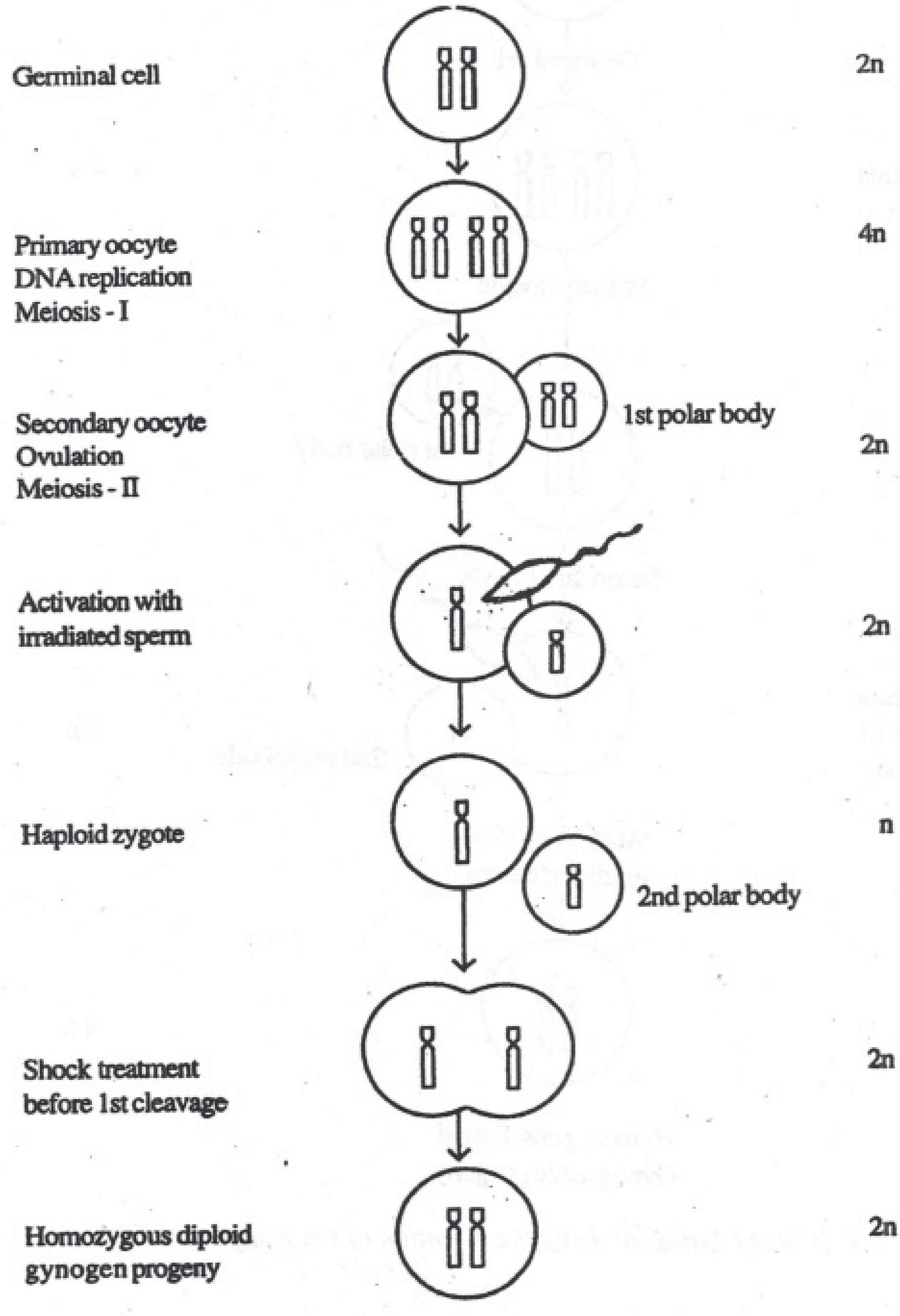


Fig. 5-6. *Induced gynogenesis by endomitosis* (blocking 1st cleavage)

The main objective of gynogenesis is to produce highly homozygous inbred lines in much shorter time than through the conventional inbreeding process (sib-mating). Through intraspecific hybridization (top-crossing) of these inbred lines, good heterosis can be achieved. Thus gynogenetic fishes can be used in constructing inbred strains for subsequent hybridization experiments. Another potential application of induced gynogenesis is in sex control for production of all female population. It helps in the control of reproduction in species where it is desirable. Further, the gynogenesis helps to produce superior strains in a shorter period of time because in many fish species, the female grows bigger with delicious meat than the male. The gynogenetic populations of catla, rohu, mrigal, calbasu, common carp, tilapia, zebra fish, salmon, trout, etc. have been successfully produced.

B. ANDROGENESIS

Androgenesis is a paternal inheritance in which the progeny derive all the chromosomes from their father only. It is also another form of parthenogenesis. The procedure for androgenesis is similar to gynogenesis, but here, the chromosomes of the egg are inactivated instead of sperm. The fertilized egg develops with only male chromosomes and all such eggs hatch male offspring. It occurs in nature and can also be induced.

a. Natural or spontaneous androgenesis: It was reported to occur when female common carp was crossed with male grass carp or bighead carp with common carp. However, the percentage of incidence was very low.

b. Induced androgenesis: In this, the genetically inactivated egg is fertilized with normal sperm of the candidate species. The zygote may develop into a haploid embryo and to restore diploidy, the zygote has to be subjected to some shock treatments, either thermal or hydrostatic pressure, at first cleavage. Androgenesis gives rise to all males where male homogamety exists. Relatively little work has been done on androgenetic technique in fish. However, viable androgenic progeny of rainbow trout, common carp, loach and tilapia have been produced.

The major application of androgenesis is in the rapid generation of inbred lines. The approach is identical in principle to that using homozygous gynogenetic diploids. Another potential application of androgenesis could be in the recovery of genotypes from cryopreserved sperm.

C. POLYPLOIDY

Polyploidy refers to the production of individuals with extra sets of chromosomes. In other words, it refers to the enhancement of genome by the addition of one or more set(s) of chromosomes to the normal diploid genome. Like gynogenesis and androgenesis, polyploidy also occurs in nature and can be induced too.

a. Natural polyploidy: Natural or spontaneous polyploidy usually occurs in fishes like common carp and trout. It is mainly due to chromosomal translocation. It also occurs when very distantly related fish species are cross bred. The cross between grass carp and big head have produced triploid hybrids.

b. Induced polyploidy: The method of inducing polyploidy is same as inducing diploid gynogenesis and androgenesis. The difference is that in polypoidy, neither egg nor sperm is inactivated, but only the normally fertilized zygote is administered the shock treatments. The remaining procedure being the same.

Polyploids are produced by treating zygote with either temperature shock, hydrostatic pressure or chemical treatment. If the treatment is applied shortly after fertilization, triploids are produced due to retention of the second polar body of the egg. If the treatment is applied shortly before the first cleavage or mitotic division (to cause endomitotis) tetraploids can be produced (Fig. 5-7).

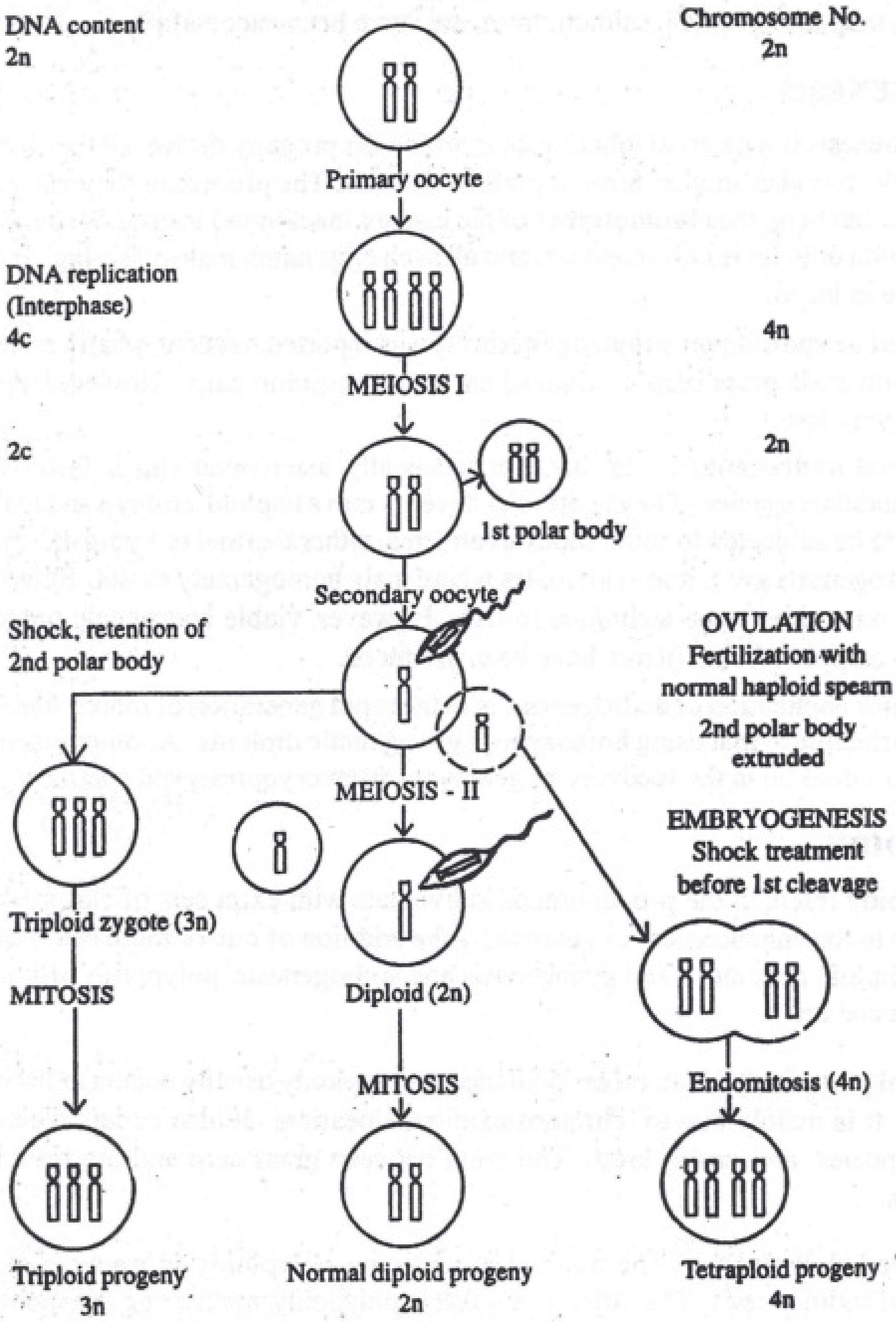


Fig. 5.7. ***Induced polyploidy***

Successful induction of triploidy has been achieved in grass carp, common carp, rainbow trout, salmon spp, plaice, gold fish, tilapia, etc. Some preliminary studies have also been made in India on the induction of triploidy and tetraploidy in Indian major carps and tilapia. The details of observations on induced polyploidy (triploidy/tetraploidy) in Indian carps, grass carp and common carp are given in Table. 5-1. Successful tetraploidy was reported in rainbow trout, tilapia species and channel catfish. Production of triploids by crossing tetraploids with diploids is a new development that holds promise as a simple and economical method.

Table 5-1 DETAILS OF INDUCED TRIPLOIDY/TETRAPLOIDY IN CARPS AT CIFA

Species	Ploidy		Shock treatment			Remarks
	Triploid	Tetraploid	Nature	Intensity	Duration	% success
Catla catla	-	Tetraploid	H.S.	40⁰	2 min	30-55%
Labeo rohita	Triploid	-	H.S.	42⁰C	1-2 min	12%
Labeo rohita	-	Tetraploid	H.S.	39⁰C	2 min	70%
Cirrhinus mrigala	-	Tetraploid	H.S.	39-40⁰C	2 min	10-40%
Ctenopharyn-godon idella	Triploid	-	H.S.	42⁰C	01 min	66-90%
-do-	Triploid	-	C.S.	12⁰C	10-15 min	33-66%
-do-	Triploid	-	HPS	8000PSI	2.5 min	90-100%
Cyprinus carpio	Triploid	-	H.S	40⁰C	01 min	70-90%

N.B. C.S. - Cold shock, H.S. - Heat shock, HPS - Hydrostatic pressure shock

Shock treatments administered to 4 min. old inseminated eggs in all the cases except to induce triploidy in rohu which was administered to 7 min. old inseminated eggs.

The primary interest in induced triploid fish lies in their sterility and this may lead to extended growth, carcass (meat) quality and survival in mature fish. Sterility is of great advantage in modern aquaculture as energy spent for maturation or gonadal development may be diverted or utilized for increased somatic growth, especially in species like common carp and tilapia which have shorter maturity cycle. Sterility is also advantageous in situations where the control of reproduction is desirable. In tilapia, to avoid early sexual maturity and very high fecundity, triploids were produced which had a size 25-30% bigger than that of the diploid because all the energy is utilized for gaining meat. Triploid grass carp can be safely used for controlling aquatic weeds in open water systems without fear of its establishment through reproduction. Sterile triploid grass carp has been found to be extremely valuable in the united states for stocking ponds and lakes for vegetation control.

Another benefit of induced triploidy is that interspecific triploid hybrids (*Oreochromis mossambicus x O. mossambicus niloticus*) frequently are more viable than the corresponding diploid hybrids, which raises the possibility of creating new hybrids for aquaculture. Induced triploidy appears to be well-established as a biotechnology tool in aquaculture, and is already being commercially applied in two important aquaculture species, the rainbow trout and the pacific oyster. In UK, triploid trouts have been used widely for aquaculture. The triploid rainbow trout-coho salmon hybrid showed increased resistance to hematopoietic necrosis virus.

5.4.4. CRYOPRESERVATION OF MILT OF FISH

Cryopreservation is a branch of cryobiology which relates to the long term preservation and storage of biological material at very low temperatures, usually at -196°C, the temperature of liquid nitrogen. The preservation of fish gametes or other biological materials is based on the principle that at very low temperatures, the physiological and biochemical activities are tranquilized, there by making it possible to keep them viable for a long period of time. Fish produce enormous eggs and sperms continuously, hence it appears that there is no need for cryopreservation of gametes. However, preservation of gametes for superior characteristics of aquaculture species is essential for preserving the elite gene pool. It allows selective breeding, hybridization and stock improvement. Cryopreservation of only the sperm/milt has been more successful in aquatic species than that of the eggs or embryos, because of their large size, complex structure and low water permeability. Cryopreserved semen is successfully used in the artificial insemination programme in cattle, horses, pigs, sheep and in poultry breeding. The cryopreservation of spermatozoa in fishes is successful in many species of fish such as *Oncorhyncus, Salmo, Salvelinus fontinalis, Hucho hucho, Thymallus thymallus, Esox lucius, Cyprinus carpio, Labeo rohita, Catla catla* and *Cirrhinus mrigala*.

Preservation of fish gametes solves a number of problems in fish culture. They are:

i) it would facilitates the establishment of gene bank and thus ensures the availability of genetic material for selection and cross-breeding studies.

ii) it facilitates the transportation of gametes from one place to another, thereby permitting exchange of sex products and encourage research groups at distant places.

iii) it is a cost effective technique in hatchery operations. It reduces the burden of maintaining large number of breeders.

iv) it solves the problem of asynchronization in gonadal maturation of males and females (e.g. mullets, *Chanos* and *Lates*).

v) it plays an important role in conservation of indigenous germ plasm as many of the indigenous species can not compete with exotic species. The gametes of the threatened species can be stored for later use by this technique.

A. GENERAL CONSIDERATIONS FOR PRESERVATION OF FISH SPERMS

a. EFFECTS OF COOLING AND FREEZING ON CELLULAR SYSTEMS

The major effect of lowered temperature is the reduced molecular action. However, the extent of cooling will determine the degree of molecular motion. All molecular motion and biological and biochemical actions cease at absolute zero temperature i.e., -273.16^{0}C. These events provide the basic mechanism for long term preservation of biological material in a genetically stable form. As no significant change of biological importance occurs below –150^{0}C, the biological materials can be conveniently stored at –196^{0}C i.e. the temperature of liquid nitrogen.

During cooling, cells may be subjected to different stresses due to 1) the reduction of temperature, 2) physical and mechanical effects of ice and 3) concentration of extracellular and intracellular solutions during freezing.

b. EFFECTS OF LOW TEMPERATURE ON CELL MEMBRANES

The cell membrane is the principal barrier between the cytoplasm and the extra-cellular environment and is therefore the prime site for cryoinjury. Most of the cell membranes consist of phospholipid subunits in which proteins are embedded to form a mosaic structure and is designed to maintain semipermeable nature in a fluid state. The effects of low temperature on membrane integrity are complex and not well understood. The lipids solidify on cooling and restrict the movement of proteins. Thus the distribution of these proteins will depend on the rate of cooling. When the membrane is cooled rapidly there is insufficient time for the protein molecules to migrate to more fluid areas within the membrane and they therefore set in a configuration similar to that found at normal temperatures. During slow cooling the proteins can migrate from the lipids and aggregate to form large protein areas. If this separation is irreversible, the membrane protein functions may not be restored upon thawing. For successful cryopreservation, the processes associated with energy production, active ion transport, enzymatic actions and membrane permeability must be restored upon warming to normal temperatures.

c. MORPHOLOGY OF FISH SPERMATOZOA

Sperm cells of fishes employing external fertilization have a simple structure in contrast to more developed structures associated with internal fertilization. The sperm cells of common carp are of primitive type, the head being spherical or slightly elliptical with 2-2.5 μm in diameter and 3.3 μm length. The midpiece contains a few mitochondria and the centrioles. An undulated membrane envelops the entire cell. The plasma membrane has one or two fin like ridges along the tail which are on a horizontal axis with the central microtubules. The morphology of sperm cells change after dilution in isotonic solutions, but in freshwater, the plasma membrane swells and the tail coils at its posterior end.

d. MOTILITY OF SPERM CELLS

Fish spermatozoa are immotile in the testes. The motility is initiated when the semen or milt comes in contact with water on release during spawning. The process of acquiring motility is termed activation. The environmental factors which stimulate motility of sperm in most cultivable species are ions (potassium, sodium, calcium and magnesium), pH and osmotic pressure which may dipolarise the cell membrane stimulating the motility.

The duration of motility of sperm cells after activation is variable. In freshwater the motility of sperm cells starts immediately after dilution which may lasts for 15 seconds in *Salmo gairdneri*, 2-3 min. in *Esox* sp and 30-60 seconds in common carp. Artificial media induce good activation in sperm cells without exposing them to extreme osmotic conditions and prolong the motility and the period of fertility. Trout spermatozoa are motile between 1-5 min in various isotonic media.

B. PRESERVATION OF SPERM

Sperm cells can be preserved for shorter or longer periods of time depending on the need.

a. **Short term preservation:** Short term preservation methods are undertaken for convenience during breeding operations. Thus at the time of stripping female fish, milt is on hand, and this will help less number of fishes to be handled at the time of breeding. The preservation of sperm is based on the principle that the low temperature reduces the metabolic activity of the cells so as to prolong their life span. For short term preservation the fish milt is maintained on ice or in a refrigerator at temperatures 0-10^{0}C and the period of storage last a few days. The sperm may be stored either diluted or undiluted. The storing of diluted milt is preferred as it keeps spermatozoa viable for a longer duration than undiluted. The diluting solution correspond to the ionic composition of seminal plasma. An ideal diluent (diluting solution) should be antibacterial, isotonic, have a good buffering capacity and good keeping quality containing nutrients, stabilizing colloids and antixidants and should not activate motility of spermatozoa.

b. **Cryopreservation of sperms (or Long term preservation)**: Long term preservation of sperm is carried out at temperatures between –20^{0}C and –196^{0}C and should ideally keep the sperm viable for several years. Such type of preservation at very low temperature is known as cryporeservation. The techniques of cryopreservation which are in practice involve rapid cooling and storage in liquid nitrogen. The available information on cryopreservation of milt is based on the work done on salmonid sperms.

The following steps are involved in the cryopreservation of sperms.

1. Collection of milt
2. Preparation and addition of diluents (extender and cryoprotectant)
3. Storage
4. Freezing.

1. Collection of milt

Milt is normally collected from healthy fishes by stripping method or by a catheter without any contamination of urine, fecal matter or mucus. The male brooders with best characteristic traits are selected and washed with ringers solution. The milt is collected in syringes or hemolysis tubes, and later preserved in glass ampules, plastic straws or often in plastic bags. They are kept at pond water temperature during the period of milt collection.

The colour, volume, density, pH and motility of sperms are to be noticed. A smear of the sample is then examined under microscope. If any abnormalities in sperm are found, the sample is discarded. If the samples are in good condition then they are put for further processing. The collected sperm in hemolysis tubes is kept in melting ice and then stored on a refrigerated surface at 4^0C.

2. Preparation and addition of diluents

Diluent is a solution consisting of an extender and a cryoprotectant mixed in different proportions depending on the requirement. The efficacy of cryopreservation is greatly enhanced if the prefrozen milt is diluted with a suitable extender. An extender is a solution which is added to the milt to prevent the depletion of energy and maintain the sperm alive but in inactive condition. Extender is consisting of inorganic and organic chemicals resembling that of blood or seminal plasma. Hence it is isotonic with semen and buffered to counteract the acidity or alkalinity of the cryoprotectant added in cryopreservation of sperm. The selection of extender is very important in the cryopreservation of sperm.

The chemical formulations of the extenders used for cryopreserving spermatozoa vary widely. There are two basic extenders. They are Mounibs medium (M) and Menezo medium (Me). In these two media BSA (bovine serum albumin) and tellurite egg yolk are added. For Indian fishes several extenders are developed by modifying the constituents. The complexity of formulations, however may not necessarily be correlated with the cryosurvival of cells. In general, simpler extenders, some containing only Nacl, $NaHCO_3$ and lecithin have been shown to be successful.

Diluted sea water and cryoprotectant have also been used with some success in herring *Clupea harengus* and mullet, *Mugil cephalus*. Recent studies with tilapias have also shown that some success can be had by simply diluting spermatozoa in tap water containing 5% methanol and 15% milk powder.

Selection of cryoprotectant: Cryoprotectants are added to extenders to minimize the stress on cells during cooling and freezing. There are a number of chemicals that have the cryoprotective qualities. Some of the commonly used cryoprotectants are Dimethyl sulphoxide (DMSO), glycerol and methanol. The cryoprotectants should have good solubility and be non-toxic to cells. The success of cryopreservation depends on the optimum concentration of cryoprotectant, freezing techniques applied and the equilibration time.

The way in which the cryoprotectants work is not well known. It appears that cryoprotection results from the suppression of salt concentration during cooling and reduction in cell shrinkage and the fraction of solution frozen at a given temperatures.

Dilution ratios: Various dilution ratios of milt and diluent are tested for different species. They range from 1:4 to 1:9 for salmonids, 1:1 or 1:2 for common carp, 1:3 for silver carp and big head.

Equilibration period: The time required for cryopreservation from the addition diluent to the milt to the immersion of ampules containing the cells in known as equilibration time. The diluent and equilibration time are significantly interrelated and therefore the equilibration time may depend on the diluents used. In case of tilapia, spermatozoa should be cooled immediately after mixing with the diluent. This may be from 40-50 minutes in the case of carp milt.

3. Storage techniques

Diluted sperm has been successfully stored in polypropylene vials (1-2 ml), as pellets (40-200 μl) and in 0.25 ml and 0.5 ml plastic straws akin to those used in cattle industry. The polypropylene vials are available with various colours of cap inserts for easy identification. The vials may be stored in racks or held end-on in cranes or aluminium clips.

Pellets of diluted semen are usually made by using a dry ice block (-79^{0}c) as the coolant. This technique is portable and can therefore be used in the field. Holes are drilled into a block of dry ice into which a fixed volume of diluted semen is added. After sometime the frozen pellets are removed and stored in vials.

In case of plastic straw preservation, diluted semen is drawn into the colour-coded straws and either heat sealed or plugged with a special colour-coded powder which gels in the presence of a liquid to form a seal. The sealed and frozen straws are stored under liquid nitrogen.

Liquid nitrozen (-196^{0}C) is the most commonly used cryogen. Frozen samples are usually stored in liquid nitrogen refrigerators by immersing under liquid nitrogen.

To manage cryobanks efficiently, it is essential to keep complete data of all stocks preserved. Samples are lablled and colour-coded to aid identification.

4. Rate of freezing

The present day techniques of cryopreservation involve storage of frozen sperms in liquid nitrogen at –196^{0}C. Initial freezing of diluted sperms may be obtained by exposing the same to liquid nitrogen vapours. Freezing should be rapid so that thermal shock is minimal and at the sametime not to allow the formation of large ice crystals. The cells can tolerate very low temperatures required for long storage but an intermediate zone of temperature (-15 to -50^{0}C) may become lethal, as a cell traverses this temperature zone twice, first during cooling and second during warming. It is therefore necessary to know how to cool sperms to a satisfactory storage temperature and warm them back to ambient temperature without killing them. Optimum cooling rates depend on the concentration of the cryoprotectant used. The optimum thawing also vary according to the above parameters. The motility of the thawed sperms once activated lasts for only a few seconds.

Cooling and thawing: The rates of cooling and thawing are the most critical variables affecting the success of cryopreservation. The studies so far indicate that the optimal rates may be species specific. For salmonids, good results have been obtained with DMSO at cooling rates of 30-35° C/min. Good post-thawed viability was obtained by using a thawing rate of 80° C/min. The optimum for salmonid spermatozoa was observed to be between 30 and 160° C/min.

5.4.5. SUMMARY

1. Biotechnological applications in recent years have assumed tremendous importance to meet the global needs in terms of food, shelter, medicines, energy, raw material for industry, etc. Biotechnology involves many technical processes employing biological organisms for specific purposes towards human welfare. Of late, biotechnology in aquaculture industry has been playing a pivotal role in increasing production through the application of several biotechnological innovations.

2. Aquaculture industry demands high yielding species mainly by way of fast growth and high food-conversion efficiency. This can be achieved by employing efficient methods of genetics and biotechnology involving the chromosomal and genetic engineering in the multibillion industry of aquaculture.

3. Genome manipulations (chromosomal engineering) or chromosomal set manipulation techniques such as gynogenesis, androgenesis and polyploidy are promising biotechnological approaches (tools) with significant application in aquaculture. Gynogenesis/Androgenesis is mainly useful in the production of monosex population, polyploidy is used for the production of sterile population.

4. Gynogenesis is the maternal inheritance in which the offsprings derive the chromosomes from their mother. It occurs in nature and can also be induced. In induced gynogenesis, the fish sperm is exposed to UV light for inactivating its chromosomes; this inactivated sperm is allowed to fertilize with the normal egg; then the egg is subjected to thermal/pressure shock treatment for a short while to develop with only female chromosomes (by suppressing the second meiotic division or endomitosis); and all such eggs hatch female offspring. The potential application of induced gynogenesis is in sex control and for rapid inbreeding.

5. Androgenesis is the paternal inheritance in which the offsprings derive the chromosomes from their father. The procedure for androgenesis is similar to gynogenesis, but here, the chromosomes of fish egg are inactivated; the fertilized egg is developed with only male chromosomes and all such eggs hatch male offspring. It occurs in nature and can also be induced. The potential application of androgenesis is in the rapid generation of inbred lines and in the recovery of genotypes from cryopreserved sperm.

6. Polyploidy refers to the production of individuals with extra sets of chromosomes. They may be triploids or tetraploids. Polyploidy also occurs in nature and can be induced too. In induced polyploidy, neither egg nor sperm is inactivated but only the normally fertilized zygote is given the shock treatments. If the treatment is applied shortly after fertilization, triploids are produced and if the treatment is applied shortly before the first cleavage, tetraploids are produced. The primary interest

in induced triploidy is that the triploids are sterile and would hopefully grow faster by avoiding gametogenesis. These fishes would thus yield high production in aquaculture especially in species like common carp and tilapia, which have shorter maturity cyde. Tetraploid fish, if fertile, can be crossed to diploid to produce triploids.

7. Cryopreservation is a technique of storage of biological material with no time limit. It is a new technique in which sperms, eggs and embryos are stored under a freezing temperature (-196°C) to ensure the availability of genetic material for selection and cross-breeding studies. It has immense importance in preserving the elite gene pool for genetic selection programmes. Preservation of fish gametes solves a number of problems in fish culture.

8. Preservation of sperm rather than eggs and embryos has been found successful in many species of fish including Indian major carps. Sperm cells can be preserved for shorter or longer periods of time depending on the need. Short term preservation methods are undertaken for convenience during breeding operations.

9. Preservation of sperm at very low temperature (-20°C to –196°C) for long term is known as cryopreservation of sperm. The technique involves rapid cooling and storage in liquid nitrogen. The steps involved in the cryopreservation of sperm are 1. collection of milt 2. preparation and addition of diluents (extender and cryoprotectant) which keeps the spermatozoa viable for long time 3. Storage in polypropylene vials or pellets or plastic straws, and 4. freezing rapidly in liquid nitrogen.

5.4.6. GLOSSARY

Androgenesis: The process by which all of the genetic nuclear material is provided by the male parent to the offspring; thus all progeny develop into males.

Asynchronization: Variation in the time of sexual maturation of male and female. At times males mature early in the breeding season and females at the end of the season. It causes considerable hindrance to successful induced breeding.

Cryopreservation: Preservation of storage of biological material including gametes at very low temperature (usually at –196°C, the temperature of liquid nitrogen) for long period with no time limit.

Endomitosis: Doubling of chromosomes without division of nucleus, producing polypoidy. Doubling may be repeated many times in a single nucleus.

Genetic engineering: Includes genomic manipulations at chromosome level and gene transfer at DNA level.

Genome manipulations / Chromosomal engineering: Direct means of genomic manipulations are concerned with the natural or artificial changes brought about in the chromosome complexity of an individual which are known as gynogenesis, androgenesis and polyploidy. Indirect manipulations are carried out through conventional hybridization.

Gynogenesis: The development of an ovum following sperm penetration, but without fusion of the gametes; thus all offsprings develop into females.

Heterosis: Hybrid vigor; the result of breeding distantly related individuals may sometimes be an increase in growth rate, food conversion efficiency, dress-out percentage, or some other desirable characteristic.

Heterozygous: Describing the condition in which one of the pair of genes responsible for a particular trait is dominant and the other is recessive.

Homozygous: Describing the condition in which both genes of a pair responsible for a particular trait are either dominant or recessive.

Parthenogenesis: The production of offspring from unfertilized egg or development of ovum without fertilization into a new individual. In many animals it may be induced artificially. All offspring are diploid and are genetically identical with the parent.

Polyploid: Having three or more times the haploid number of chromosomes and theindividuals are generally sterile.

Sterility: Unable to reproduce sexually.

Tetraploid: Having four times the haploid number of chromosomes in a nucleus. A form of polyploidy.

Thawing: The melting of ice or snow by warming.

Triploid: Having three times the haploid number of chromosomes in a nucleus. A form of ployploidy.

5.4.7. MODEL QUESTIONS

1. Explain the biotechnological approaches with reference to induced gynogenesis, and rogenesis and polyploidy in fishes.

2. Describe the general considerations and technique of cryopreservation of spermatozoa in fish.

3. Write notes on

   a. Gynogenesis b. Androgenesis

   c. Polyploidy d. Cryopreservation of sperm

5.4.8. REFERENCE BOOKS

Sinha, V.R.P. and H.C. Srivastava, 1995. *Aquaculture Productivity.*

Reddy, P.V.G.K., Kanta Das Mohapatra, H.K. Barman, R.K. Jana and J.N. Saha, 1997. *Genetic Improvement Mehtods in Asiatic carps.* Manual Series (4): 42 pp. Central Institute of Freshwater Aquaculture, Bhubaneswar, India.

Lakra, W.S. *Chromosome engineering in Aquaculture. In: Genetics and Biotechnological tools in Aquaculture and Fisheries.* Manual CAS Training Programme, December 2-31, 1998. Fish Genetics and Biotechnology Division, Central Institute of Freshwater Aquaculture, Bhubaneswar, India.

Diwan, A.D. *Principles of biological cryopreservation and cryopreservation of fish gametes. In : Genetics and Biotechnological tools in Aquaculture and Fisheries,* Manual CAS Training Programme, December 2-31, 1998. Central Institute of Freshwater Aquaculture, Bhubaneswar, India.

Gupta, S.D. *Cryopreservation of carp milt. In: Training manual on Biotechnology in Aquaculture,* 24 March – 9 April, 1992. Central Institute of Freshwater Aquaculture, Bhubaneswar, India.

Dr. P. PADMAVATHI

UNIT – I

LESSON - 1.1

INTRODUCTION TO AQUACULTURE:

SIGNIFICANCE, HISTORY, CULTIVATED SPECIES, CULTURE SYSTEMS AND CLASSIFICATION OF AQUACULTURE

1.1.1. Objectives
1.1.2. Introduction
1.1.3. Significance of aquaculture
1.1.4. History of aquaculture
1.1.5. Major cultivated species in different parts of the world
1.1.5.1. Fin-fishes
1.1.5.2. Shell-fishes
i) Crustaceans
ii) Molluscs
1.1.5.3. Sea weeds
1.1.6. Culture systems
1.1.7. Classification of aquaculture
1.1.8. Summary
1.1.9. Glossary
1.1.10. Model Questions
1.1.11. Reference Books

1.1.1. OBJECTIVES

The purpose of this lesson is

* to introduce the subject of aquaculture by explaining its importance, historical background, different groups of cultivated species all over the world, the culture systems and its classification.

1.1.2. INTRODUCTION

Aquaculture is defined as "the rearing of aquatic organisms under controlled or semi-controlled conditions". The other definition of aquaculture is "the rearing of desirable aquatic organisms under confined conditions for economic or social benefits". Another definition is simply "the large scale husbandry or rearing of aquatic organisms for commercial purposes". Thus aquaculture is concerned with the propagation and rearing of aquatic organisms under complete human control involving the manipulation of at least one stage of their life before harvest in order to increase their production. It includes the culture of fishes; crustaceans like prawns, shrimps, crabs, lobsters;

molluscs like oysters, mussels, clams, snails; **echinoderms** like sea urchins and sea cucumbers; **frogs**; marine plants like **sea weeds**, etc. Of these cultivable organisms, fishes (class Pisces) are referred to as **fin-fishes** and the crustaceans and molluscs are referred to as **shell-fishes**. In India, the culture of freshwater major carp and prawn, and brackishwater shrimp assumed great importance in recent years.

Aquaculture is an age old practice and developed into a modern science during recent years. Aquaculture has become one of the most lucrative of the farming practices. Capture fisheries have been the main source of our fish production. However, the production from capture fisheries has not been increasing in recent times because of pollution and over exploitation of the natural stocks all over the world. As an alternative, aquaculture appears to be the most suitable means of increasing fish production.

Aquatic organisms are the most important source of animal proteins to the people. An abundant low cost protein rich food through aquaculture production will solve the problem of balanced diet of people. The aquatic resources of our country are rich and varied in terms of types of both water and species of fish and shellfish. Aquaculture also provides scope for waste water utilization to produce food. The utilization of aquatic resources to a maximum extent (aquaplosion) for getting higher food production has led to **Blue revolution.** With the blue revolution, the country can not only meet the food demands of the people but also earn foreign exchange. Thus aquaculture has the potential of being the second largest means of food production next only to agriculture.

1.1.3. SIGNIFICANCE OF AQUACULTURE

- Aquaculture has acquired a special significance not only because of its contribution to food resources but also of its contribution to commercially important products like body oils, liver oils with vitamin A & D, fish silage, shaagreen, isinglass, fish guano, fish manure, fish glue, fish caviar, fish fins, etc. from fishes; pearls, chanks, *Artemia* cysts, etc. from molluscs and crustaceans, and agar from sea weeds, etc..
- Aquaculture gives higher productivity per unit area as compared to agriculture or animal husbandry.
- Food conversion rate is 1.5 to 2 times higher than in chicken, sheep, beef or other red meat.
- Aquaculture, especially 'integrated fish farming with agriculture and animal husbandry' is known to be more profitable.
- Recycling of agricultural and animal wastes is possible in aquaculture, so as to help and protect our environment.
- Artificial recruitment in seas, rivers, lakes or reservoirs by fish seed produced through aquaculture called sea ranching or aqua range farming helps in increasing existing fish stocks.
- It generates more employment opportunities to both educated and uneducated people and arresting the migration of people from rural to urban areas.
- It is suitable to small scale family managed operations and it can be integrated with agriculture and small scale fisheries.

- It helps in overall development of rural areas through integrated projects, including aquaculture and by promoting agro-industrial development.
- It is earning foreign exchange through export or saving foreign exchange through import substitution.
- It converts wastelands into productive ones.
- It has significance in creating and maintaining leisure-time activities, including sport fishing, and home and public aquaria.
- From the nutritional point as well, aquaculture has a special significance. Fish and fishery products are considered superior to red meat in many parts of the world. The fish food is not only easily digestible but is also rich in essential amino acids like **lysine** and **methionine,** thus having high biological value. Fish fat has **polyunsaturated fatty acids (PUFA)** mostly of easily digestive nature and medicinal value. The unique PUFA namely **eicosapentaenoic acid** of fish is known to reduce the cholesterol level of blood and save human beings from coronary diseases. Further, vitamins such as A,B,D and minerals like calcium, phosphorus, iron, sodium, potassium, magnesium and sulphur are also present in good quantities in fish.

1.1.4. HISTORY OF AQUACULTURE

Aquaculture has a long history in Asia, ancient Egypt and in Central Europe. Egyptians were probably the first in the world to culture fish as far back as 2500 BC. In China, carps are known to have been spawned and reared about 2500 years ago. The founder of the Chou Dynasty, Wen Fang is called the first fish farmer. The *Classic of Fish culture* written around 500 BC by Fan Lei, a Chinese politician-turned-fish culturist, is considered proof that commercial fish culture existed in China in his time. During the Tang Dynasty, 1400 to 110 years ago, major break through in carp culture came with the initiation of polyculture. The earliest form of fish culture appears to be of the common carp (*Cyprinus carpio).* Later it was introduced into Asia, Far East and other countries all over the world.

While the Chinese immigrants were the focal points for most of the developments of fish farming in Southeast Asia, indigenous systems of Indian carp culture seem to have existed in eastern parts of the Indian subcontinent in the 11th century AD. The early systems of pen and cage culture of catfish appear to have originated in Cambodia, present-day Kampuchea.

The earliest brackishwater farming with milk fish (*Chanos chanos)* in Southeast Asia appears to have originated in Indonesia in the Island of Java during the 15th century AD. With the technology passed down from the Egyptians, Romans cultivated mullets and other fish in the Italian coast. Besides fish, bivalve molluscs have also been cultivated due to their great popularity as food.

The propagation of trout for sport fishing, which has a fairly long history, originated in France during 14th centrury. Commercial trout culture in fresh water on large scale developed in countries like France, Denmark, Japan and recently in Italy and Norway. The British introduced trout in their colonies in Asia and Africa, mainly to develop sport fisheries. The early development of fish culture in North America (18th century) was centered on the propagation of salmon and trout and to a lesser extent on the black bass. Slowly the practice of trout farming in open waters spread to the temperate and semi-temperate areas of central and South America.

The breeding and rearing of ornamental fish such as goldfish was rather an ancient practice by the Japanese and the Chinese. The spread of tilapia, a native of the African continent, to several countries in all parts of the world is a remarkable phenomenon. It was considered as a pest by some, especially in developing tropical countries. Tilapia culture was considered as an easy means of producing cheap proteins for the masses. In recent years, solutions for some of the problems of culturing tilapia were found and commercial farming has developed in certain areas.

The oldest form of coastal aquaculture is probably oyster farming, and the Romans, Greeks and Japanese are believed to be the earliest oyster farmers. In Japan, oyster culture in intertidal stretches is said to have been practised around 2000 years ago. Romans farmed the oysters during 100 BC and then developed the culture of other molluscs, like mussels and clams.

From a historical point of view, the only other culture system that needs mention is the large-scale farming of seaweeds, which is of relatively recent origin. The first book on seaweed culture was published in Japan in 1952. After the second world war, culture of edible seaweeds expanded and intensified considerably and spread to other countries like Korea, Taiwan and China.

1.1.5. MAJOR CULTIVATED SPECIES IN DIFFERENT PARTS OF THE WORLD

1.1.5.1. FIN-FISHES

A. CARPS (Family Cyprinidae): Of the species of fin-fish and shell-fish used for aquaculture, carps undoubtedly have the oldest history.

a) Common carp: The common carp (*Cyprinus carpio*) is presently cultured all over Asia, in most parts of Europe including the USSR, and on a small scale in some countries of Africa and Latin America (particularly Brazil). It has also been introduced in North America and Australia. There are several varieties or races of common carp used for culture in different parts of the world (Fig. 1-1).

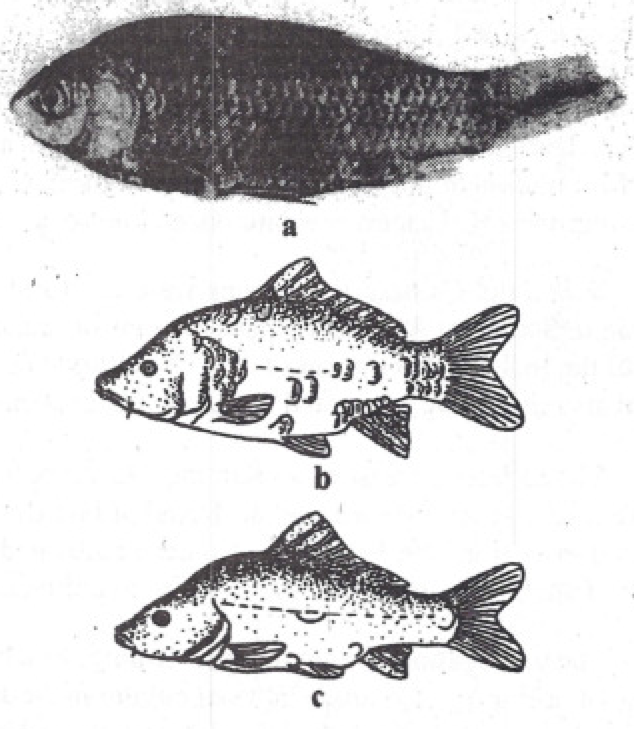


Fig. 1-1. a) *Cyprinus carpio* var. *communis* b) *Cyprinus carpio* var. *specularis* c) *Cyprinus carpio* var. *nudus*.

b) Chinese carps: The five species of carps referred to as Chinese carps are the grass carp (*Ctenopharyngodon idella*), the silver carp (*Hypophthalmichthys* *molitrix)* (Fig. 1-2), the bighead *(Aristichthys nobilis)* the black carp *(Mylopharyngodon piceus)* and mud carp *(Cinhina molitorella)*. The other carps like crucian carp *(Carassius auratus)* and wuchan fish *(Megalobrama amblycephala)* are also cultured along with Chinese and/or Indian carps in polyculture systems in China.

Many countries in Asia (including India), some in the middle east (particularly Israel and Egypt) and some countries in South America (especially Mexico) have introduced chinese carps for pond culture. The main interest in Western Europe and the USA has been in using the grass carp as a biological weed control agent.

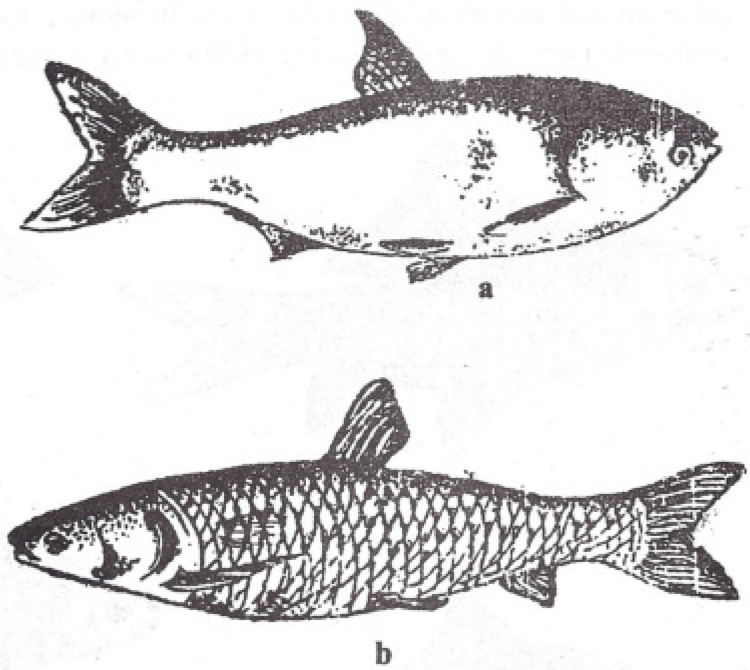


Fig.1-2 a) Silver carp b) Grass carp

c) ***Indian carps:*** Major carps like catla (*Catla catla)*, rohu (*Labeo rohita*) and mrigal (*Cirrhinus mrigala)* (Fig. 1-3) and medium and minor carps like *Labeo calbasu, L. fimbriatus, L. gonius, L. bata, Puntius pulchellus, P. kolus, P. sarana, Cirrhinus cirrhosa and Amblypharyngodon mola* are

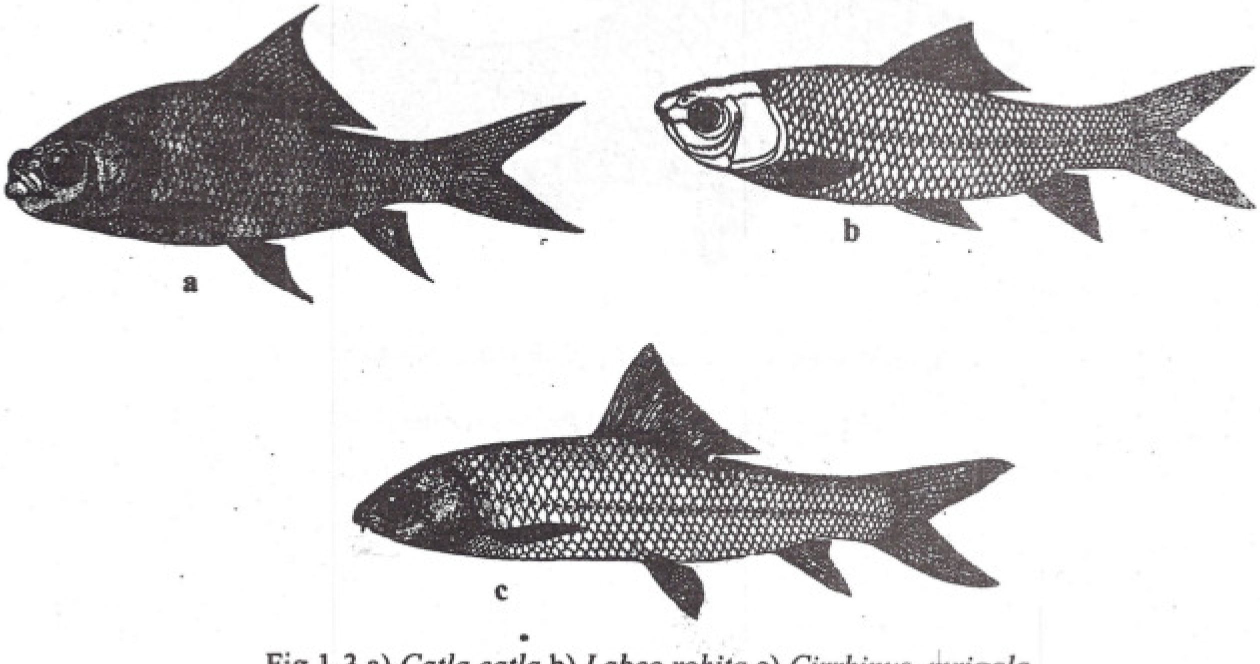


Fig.1-3 a) *Catla catla* b) *Labeo rohita* c) *Cirrhinus mrigala* the cultivated species in India (Fig. 1-4). In addition to the polyculture of Indian carps alone, composite carp culture of Indian and Chinese carps is also practised for getting higher yields in India.

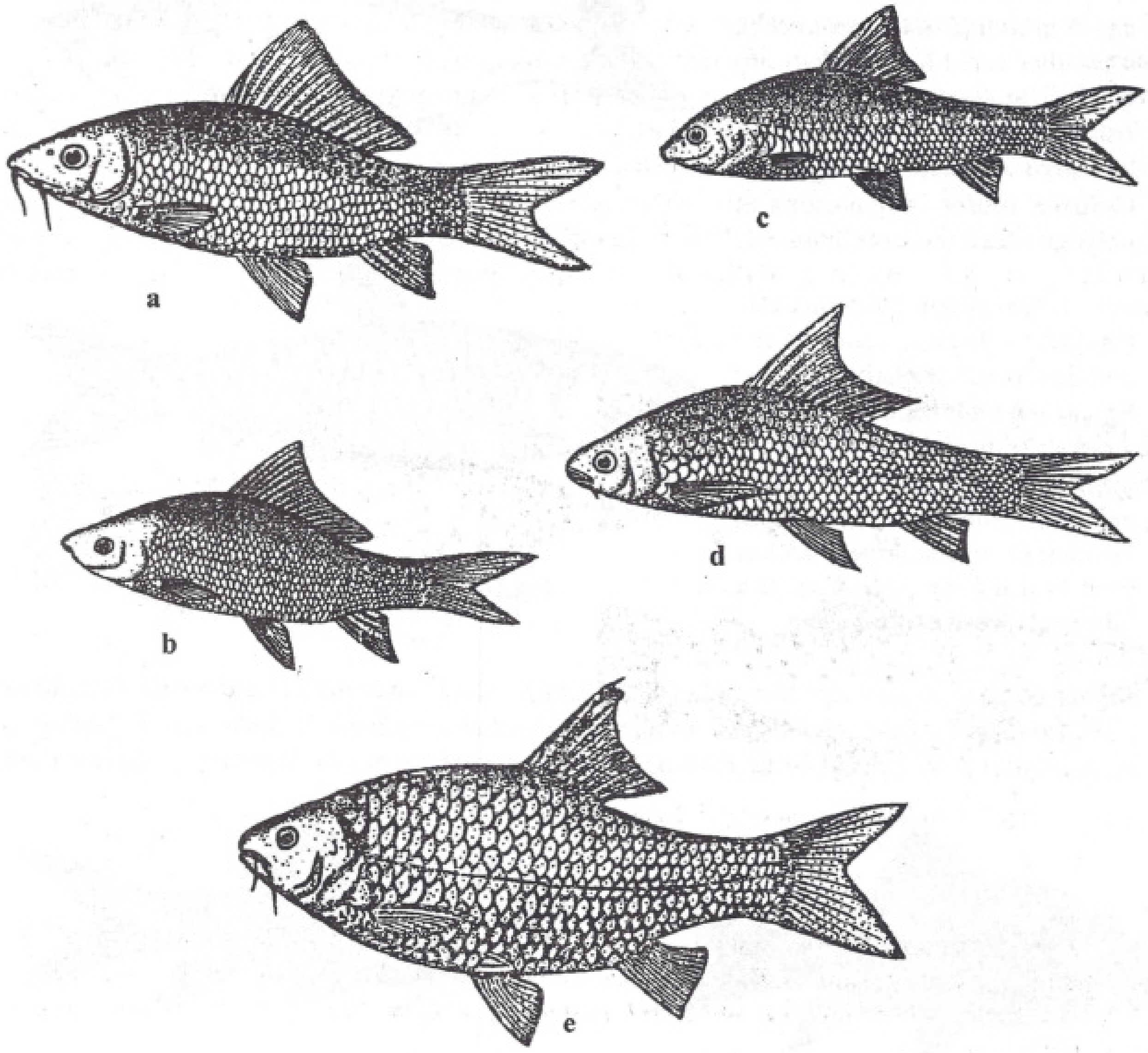


Fig. 1-4. a) *Labeo calbasu* b) *L. fimbriatus* c) *L. bata.*

d) *Cirrhinus cirrhosa,* e) *Puntius sarana*

B. TROUTS AND SALMONS (Family Salmonidae)

Salmonid culture has a relatively long history in Europe and North America. The **trout** species of the greatest importance in aquaculture is the rainbow trout (*Salmo gairdneri)* (Fig. 1-5a,b). Native to the pacific coast drainages of North America, the rainbow trout has been introduced from 1874 to waters of all continents except Antarctica. Trout waters are maintained in the upland areas of many tropical and sub-tropical countries of Asia, East Africa and South America. Commercial trout farming has developed in Central and South America and to a limited extent in some Asian and African countries like India and Kenya. The other cultivable species of importance are the brown trout (*Salmo trutta)* (Fig. 1-5c), indigenous to central and Western Europe and brook trout (*Salvelinus fontinalis),* native to north-eastern North America and introduced into Europe and to other areas where the water temperature is between 12 and 14°C.

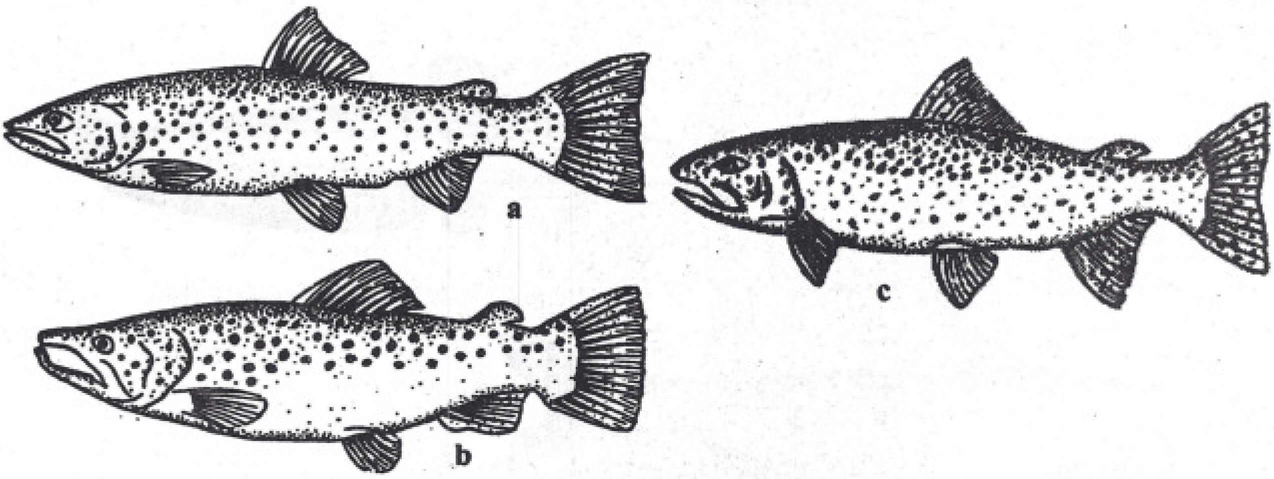


Fig. 1-5. a) *Salmo gairdneri gairdneri* (female), b) *Salmo gairdneri gairdnerl* (male)
c) *Salmo trutta*

Several species of Pacific Salmon (*Oncorhynchus)* such as the chinook or king salmon (*O. shawystscha)*, the sockeye salmon (*O. nerka),* the coho salmon (*O. kusutch)*, the chum or dog salmon (*O. keta)* and the pink or humpback salmon (*O. gorbuscha)* and the Atlantic Salmon (*Salmo salar)* have culture importance.

C. CATFISHES

Catfishes belonging to Ictaluridae, Claridae, Pangasidae and Siluridae are widely distributed in different parts of the world. Channel catfish (*Ictalurus punctatus)*, the main species used in farming in USA, has been transplanted to a number of countries in Southern Europe, Africa and Central America. The others like the white catfish (*I. catus)*, and the blue catfish (*I. furcatus)* also have farming potential.

The most important cultivable species in Asia is the Asian catfish, *Clarias batrachus* (Fig. 1-6a). Commercial culture of this is undertaken on a large scale in Thailand. Another important species is *C. macrocephalus*. In eastern India and Bangladesh, partly improved swamps are used for growing these species along with another catfish, *Heteropneustes fossilis* (Fig. 1-6b), the climbing perch *Anabas* *testudineus* and the snakeheads or murrels, *Channa* spp. In Thailand and Kampuchea, another important Asian catfish *Pangasius sutchi* has been cultured in ponds and cages for many years. Two other species cultured in ponds are *P. larnaudi* and *P. pangasius* (Fig. 1-6c).

The species of greater importance in Africa is the African catfish, *Clarias lazera* (=*C. gariepinus*, the sharp tooth catfish). Catfish farming in south eastern Europe is based on the sheat-fish or wels, *Silurus glanis*.

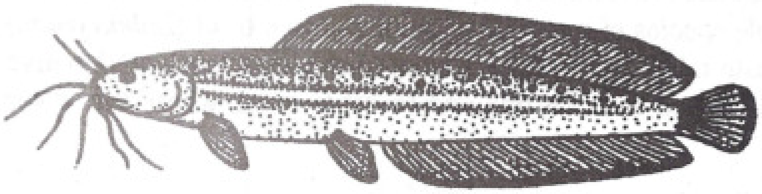


Fig. 1-6 a) *Clarias batrachus*

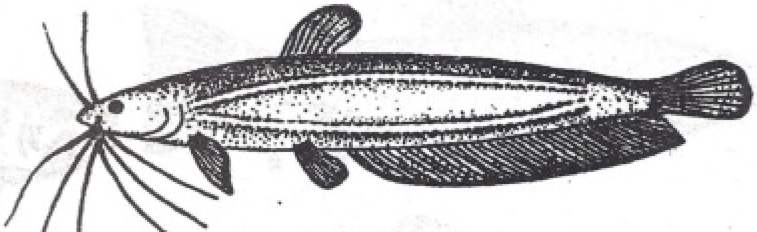


Fig. 1-6 b) *Heteropneustes fossilis*

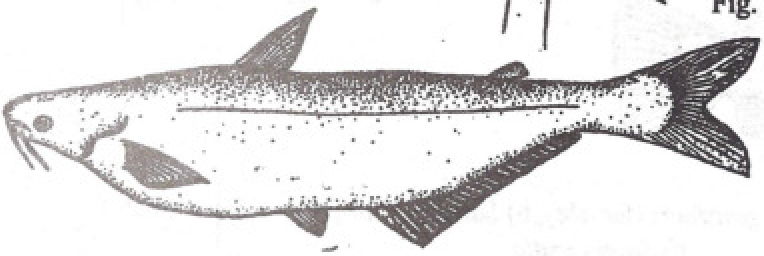


Fig. 1-6 c) *Pangasius pangasius*

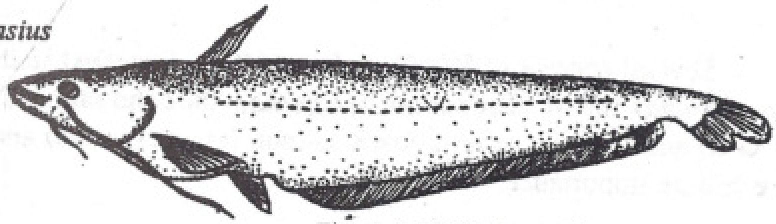


Fig. 1-6 d) *Wallago attu*

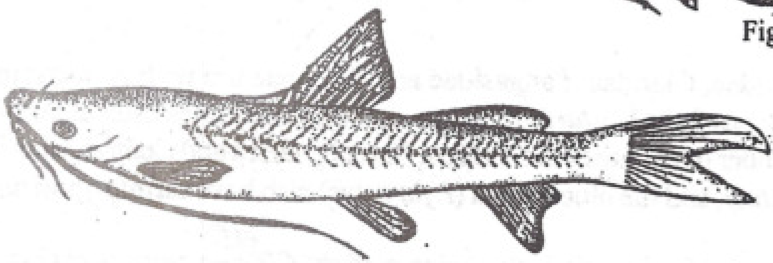


Fig. 1-6. e) *Mystus seenghala*

D. EELS (Family Anguillidae)

Although there are 16 species of eels, the most important species of large-scale aquaculture are the European eel, *Anguilla anguilla* (=*vulgaris*) in Europe and the Japanese eel, *A. japonica* in Japan and Taiwan (Fig. 1-7).

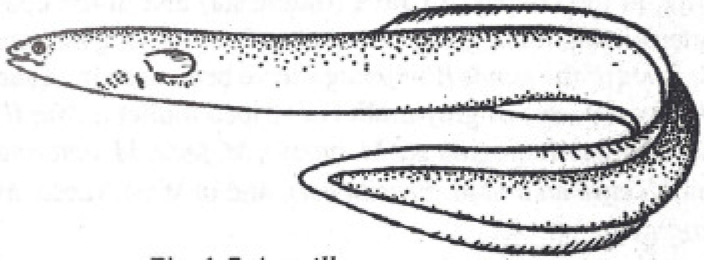


Fig. 1-7 *Anguilla*

Traditionally, western Europe and Japan are the main areas where there is high demand for eels. In Italian lagoons, eels form an important polyculture species, with grey mullets, seabream and seabass. Eel culture enterprises have developed in a number of countries in Europe, especially Italy, Germany and France. Taiwan has become a major exporter of cultured eels to Japan.

E. TILAPIAS (Family Cichlidae)

Tilapias are natives of Africa. At present they are distributed all over the world. Of the total 77 species of *Tilapia*, 22 species have been used in fish culture. Based on the breeding behaviour, the genus *Tilapia* has been divided into 3 genera. The substrate spawners, which make nests on the bottom of water bodies and spawn in them, retained the name *Tilapia* and the mouth brooders, which incubate the fertilized eggs in the mouth of the female or male parent, came under a new genus *Sarotherodon* (meaning 'brush toothed'). Later, a new genus *Oreochromis* was erected to accommodate species which spawn in nests on the bottom of water bodies, but brood the eggs in the mother's mouth. There are several other classifications and a number of sub-genera of *Tilapia* are recognised. To avoid confusion among aquaculturists regarding the frequently changing nomenclature, the generic name *Tilapia* is commonly used for all the species.

For commercial aquaculture, the more important species of tilapia are *T. rendalli, T. zilli, T. mossambica* (Fig. 1-8), *T. hornorum, T. nilotica, T. aurea* and *T. melanotheron.* Two other species, *T. andersonii* and *T. spilurus* also seem to be of some importance. Tilapias are euryhaline and grow well even in brackish and salt waters.

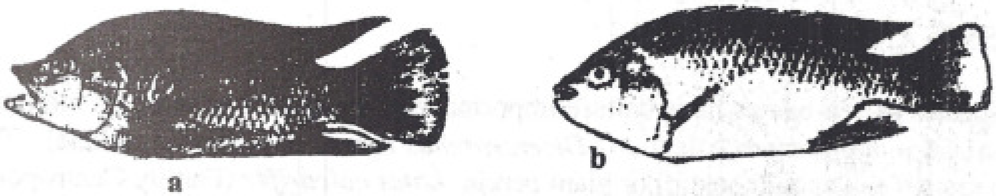


Fig. 1-8. *Tilapia mossambica* a) male b) female

F. GREY MULLETS AND MILKFISH

Grey mullets (Family Mugilidae) and the milk fish (Family Chanidae) have been the mainstay of finfish culture in coastal and estuarine impoundments for centuries. In the valleys of the Mediterranean lagoons (especially Italy), in the coastal 'harbour culture' in Northern China, in the bheries of the Gangetic estuaries in India, in the tambaks of Java (Indonesia) and in the coastal fish ponds of Hawaii, the grey mullets formed an important group of cultured fish. Among mullets, 13 valid species of the genus *Mugil* and one species of the genus *Rhinomugil* have been used in aquaculture. The most widely distributed and well known species of grey mullet or striped mullet is *Mugil cephalus* (Fig. 1-9a). Other species used in the Indo-pacific region are *M. parsia, M. tade, M. macrolepis, M. soiuy and R. corsula.* In South America *M. curema and M. brasiliensis,* and in West Africa, *M. falcipinnis* and *M. grandisquamis* are the important species.

The milkfish, *Chanos chanos* (Fig. 1-9b) the only species of the family Chanidae has culture importance. Milkfish farming is popular only in Indonesia, the Philippines and Taiwan and to some extent in peninsular India and Sri Lanka.

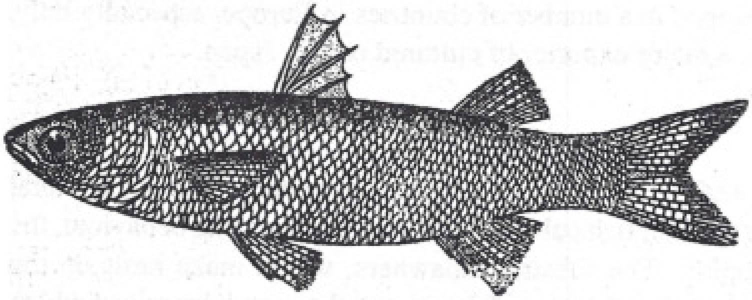


Fig. 1-9 a) *Mugil cephalus*

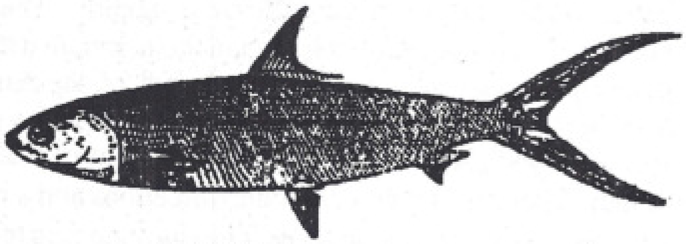


Fig. 1-9 b) *Chanos chanos*

G. YELLOW TAIL (Family Carangidae)

The yellow tail, *Seriola quinqueradiata* is the only carangid that contributes significantly to aquaculture production. Its culture is restricted to Japan. It contributes more than 90% of the total finfish mariculture in Japan.

H. SEA-BASSES AND SEA-BREAMS

Two species of sea-basses have culture importance. The European sea-bass common in the Mediterranean and in the Eastern Atlantic is *Dicentrarchus labrax* (Family Serranidae). The Asian sea-bass, also known as kakap (cockup) or giant perch, *Lates calcarifer* (Family Centropomidae) is distributed in the littoral waters from Iran to Australia (Fig. 1-10).

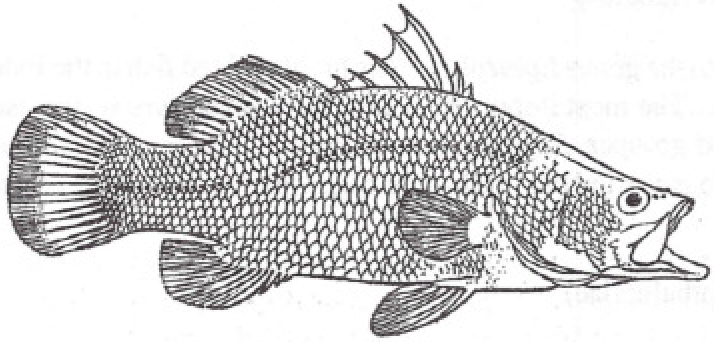


Fig. 1-10. *Lates calcarifer* (Bloch)

The Sea-breams (Family Sparidae) of aquaculture interest are the gilt head sea-bream, *Sparus auarata,* common in the Mediterranean (also in the Black sea and the eastern Atlantic), and the red sea-bream, *Pagrus major* of Japan, which occurs also in the East China sea and Southeast Asian waters.

I. MURRELS (Family Channidae)

There are over 30 species of murrels or snakeheads distributed in tropical Asia, including Northern China, and in Africa. Among these, the species of aquaculture importance are *Channa (=Ophiocephalus) striatus, C. marulius, C. punctatus* (Fig. 1-11)., *C. maculatus* and *C. micropeltes*. They are essentially freshwater species, but can withstand low salinity, brackishwater conditions. Though cultivated in many countries of Asia, murrel culture has not yet developed to major commercial importance.

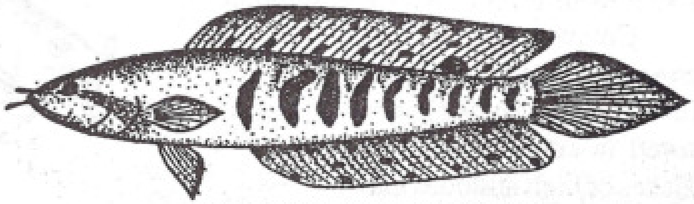


Fig. 1-11. a) *Channa striatus*

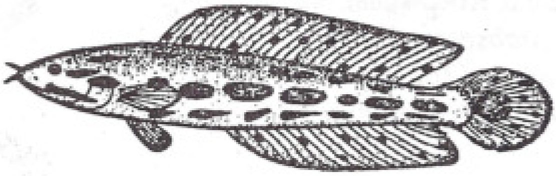


Fig. 1-11. b) *Channa marulius*

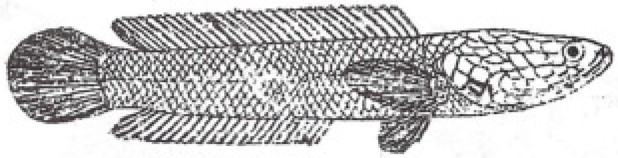


Fig. 1-11c). *Channa punctatus*

J. GOURAMIS

The three species known as gouramis are the giant gourami, *Osphronemus goramy* (Family Osphronemidae) (Fig. 1-12), the Siamese gourami or sepat siam, *Trichogaster pectoralis* (Family Osphronemidae), and the kissing gourami, *Helostoma temmincki* (Family Helostomidae). Their culture is restricted to small-scale extensive farming in some of the Southeast Asian countries.

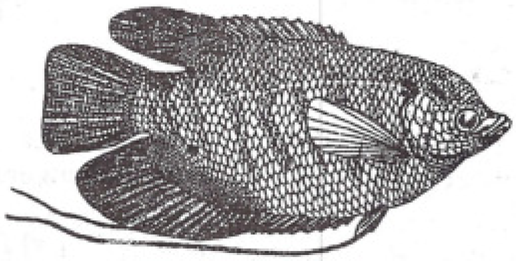


Fig. 1-12. *Osphronemus goramy*

K. GROUPERS (Family Serranidae)

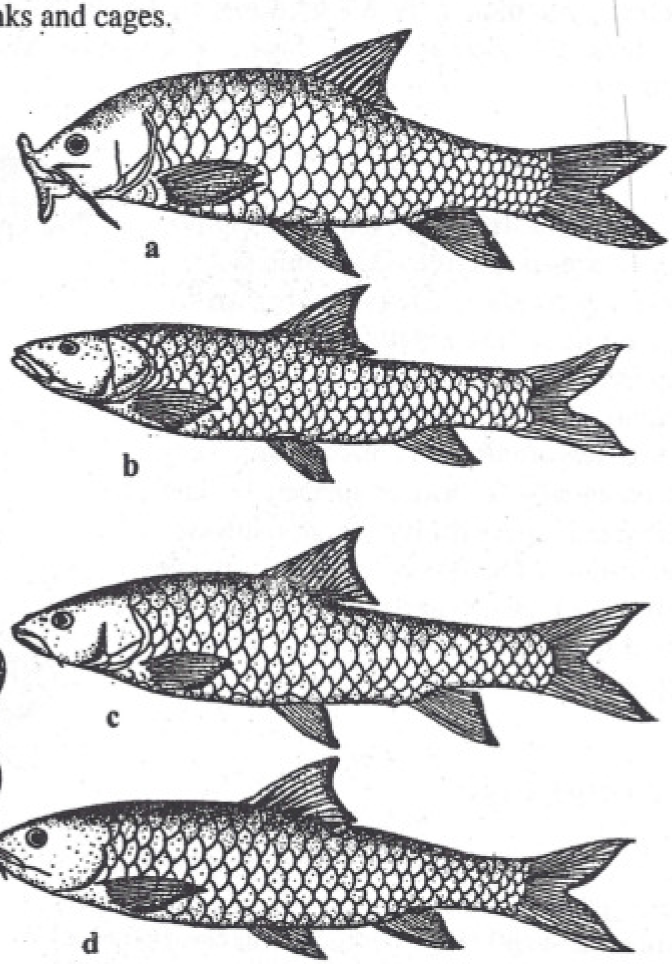
Groupers belonging to the genus *Epinephelus* are highly priced fish in the Indo-pacific, middle East and Caribbean regions. The most important species for aquaculture is the estuarine or greasy grouper *E. tauvina.* The red grouper, *E. akaar,* is the important species for culture in Hong Kong. Commercial grouper culture is carried out in floating cages on a small scale in Malaysia, Singapore and Hong Kong.

L. TURBOT (Family Scophthalmidae)

Turbot is a highly priced marine fish for which there is a good demand, especially in Northern European markets. Among flatfishes, the turbot (*Scophthalmus maximus)* has the greatest aquaculture potential. Pilot-scale production in the United Kingdom, France and in Spain has been initiated in recent years by intensive culture systems in tanks and cages.

M. SPORT FISH

Coldwater fish such as **salmon** and **trout** of sport value (game fishes) are cultured in cold water tanks and lakes of high attitudes like Kashmir, Himachal Pradesh, Ootacamund, Kodaikanal, etc. in India. ***Mahseers*** (*Tor* spp.) and **Tenches** (*Tinca tinca)* also have sport value (Fig. 1-13).



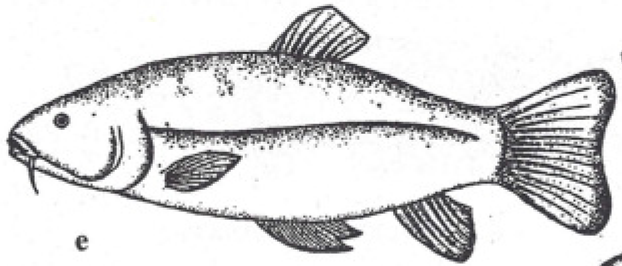


Fig. 1-13. a) *Tor tor* b) *Tor putitora* c) *Tor khudree* d) *Acrossocheilus hexagonolepis*

e) *Tinca tinca*

N. ORNAMENTAL FISH

Aquarium fish species such as goldfish (*Carassius auratus*), siamese fighter (*Betta splendens*), guppy (*Lebistes reticulatus*), platy (*Xiphophorus maculatus*), swordtail (*Xiphophorus helleri*), gourami (*Trichogaster trichopterus*), molly (*Mollienisia latipinna*) and panchax (*Aplocheilus panchax*) are taken up for culture in freshwater aquaria as a hobby or as a commercial venture in earning foreign exchange (Fig. 1-14). Similarly several marine fishes are also cultured for the above mentioned purposes.

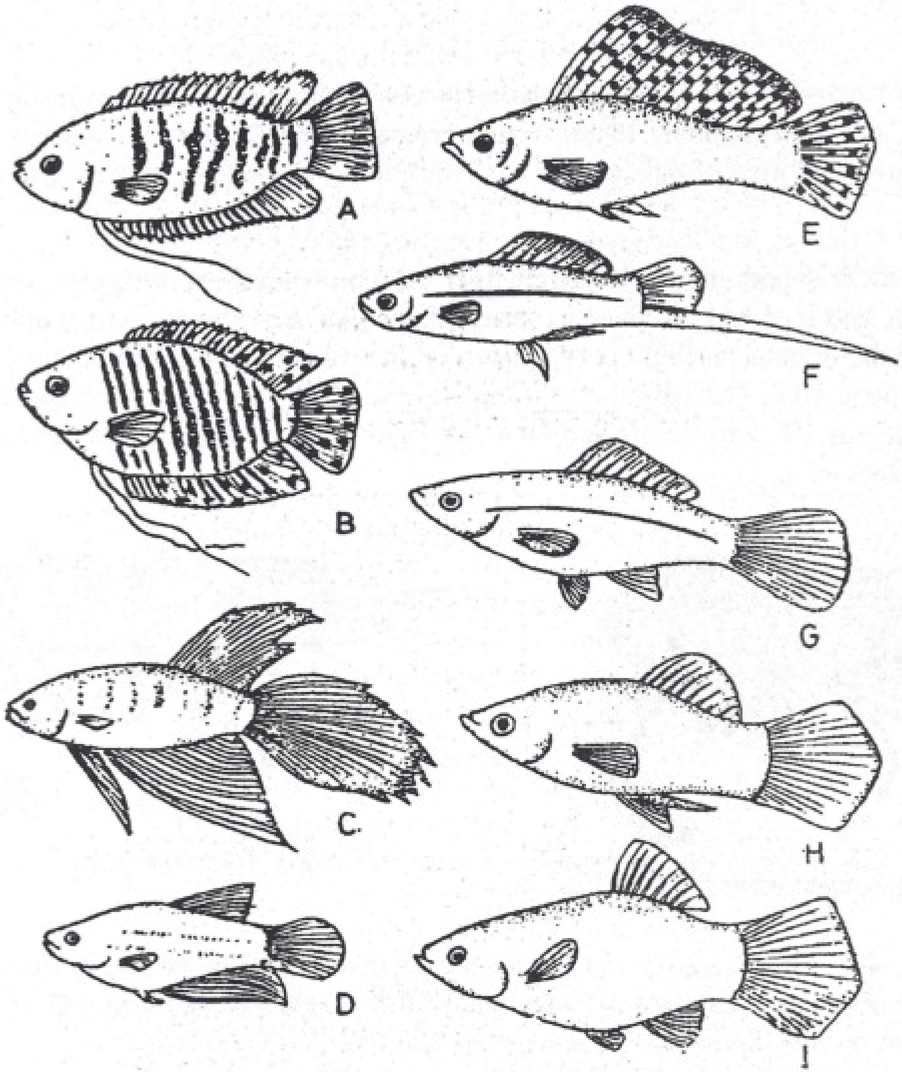


Fig. 1-14. Common ornamental fish species

A) *Colisa fasciata;* B) *Colisa lalia;* C) *Betta splendens* (male); D) *Betta splendens* (female); E) *Mollienisia latipinna;* F) *Xiphophorus helleri* (male); G) *Xiphophorus helleri* (female) H) *Xiphophorus maculatus* (male), I) *Xiphophorus maculatus* (female)

O. LARVIVOROUS FISHES

Gambusia, Oryzias, Aplocheilus, Esomus, Panchax, etc. feed on mosquito and other insect larvae. They are grown in tanks, wells, reservoirs, stagnant water pools, etc. to control the insect vectors and spread of diseases.

1.1.5.2. SHELL-FISHES

i) CRUSTACEANS

A) SHRIMPS

The popular names shrimps and prawns have been used variously to denote crustaceans of the families Penaeidae and Palaemonidae. In most recent aquaculture literature the name prawn appears to be used for freshwater forms of palaemonids and shrimp for the others, particularly the marine species.

In Asia, the more important species are the tiger shrimp, *Penaeus monodon*, and the Indian or white shrimp *P. indicus* (Fig. 1-15). The banana shrimp *P. merguiensis,* the green tiger or bear shrimp *P. semisulcatus* and the oriental shrimp *P. orientalis* (= chinensis) are also of commercial interest in some countries of the region. The red-tailed shrimp *P. penicillatus* is a species cultured in Taiwan. *Metapenaeus monoceros, M. brevicornis* and *M. ensis* form subsidiary species in shrimp farms in several Asian countries.

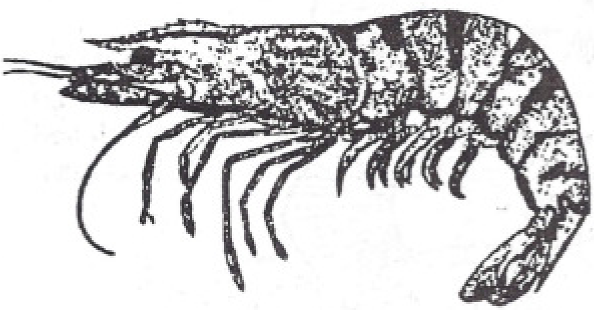


Fig. 1-15. a) *Penaeus monodon*

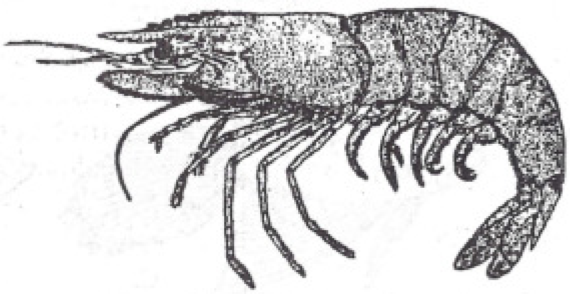


Fig. 1-15. b) *Penaeus indicus*

Penaeus japonicus is cultured in Japan, Taiwan and in a less intensive way in Brazil, France, Spain and Italy. *P. orientalis* is cultured in Korea and China. *P. setiferus* is the species of interest in the temperate regions of the USA.

In the Mediterranean countries of Europe, the main interest is on the local Mediterranean shrimp (triple-grooved shrimp) *P. kerathurus* besides the imported *P. japonicus*. Shrimp farming in Africa mainly involves the culture of *P. indicus* on the East Coast and *P. notialis* on the West coast. The most important species in Central and South America are the white-leg shrimp. *P. vannamei* and the blue shrimp, *P. stylirostris*. In the countries bordering the Atlantic coast of central and South America, the brown shrimp, *P. azeticus*, pink shrimp, *P. duorarum* and the common or white shrimp, *P. setiferus* are the important species. Of all the above potential species for commercial fish farming, the bulk of the present production comes from the farming of *P. monodon, P. indicus, P. merguiensis, P. japonicus* and *P. vannamei.*

B) PRAWNS

The species of freshwater prawns used for aquaculture belong to the genus *Macrobrachium* which is circumtropical in distribution. By far the most widely farmed species is the Giant Freshwater Prawn, *Macrobrachium rosenbergii* (Fig. 1-16). The other species worth mentioning are *M. nipponense* (East and Southeast Asia), *M. malcolmsonii* (Peninsular India), *M. gangeticum* (North-eastern India), *M. vollenhovenii* (Africa) and *M. acanthurus* (Western Hemisphere).

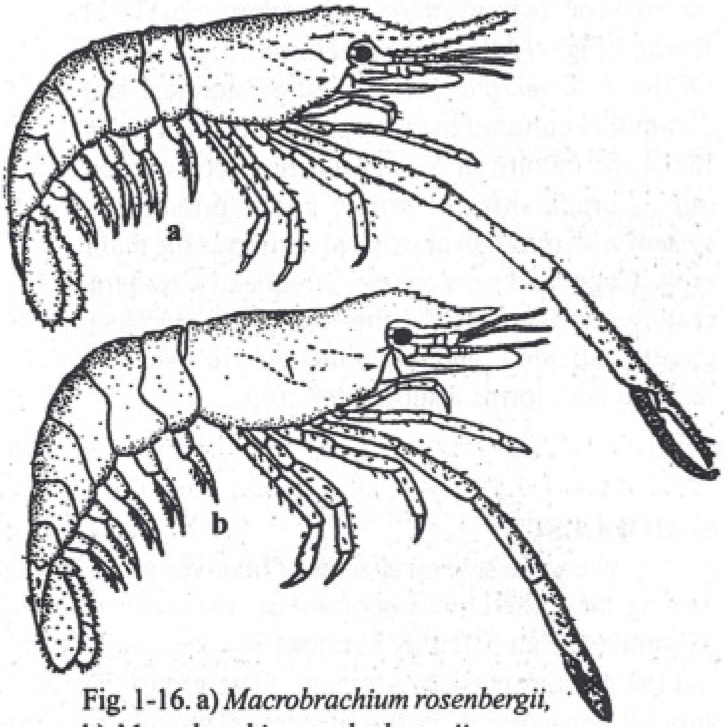


Fig. 1-16. a) *Macrobrachium rosenbergii,* b) *Macrobrachium malcolmsonii*

C) CRAYFISHES

Crayfishes belonging to the families Cambaridae and Astacidae are widely distributed all over the world. Among 300 species of crayfish, only four such as *Procambarus clarkii* (red swamp crayfish), *Pacifastacus leniusculus* (signal crayfish), *P. acutus* (white river crayfish) and *Oreonectes immunis* (paper-shell crayfish) have culture importance in USA. Crayfish is cultured in ricefields, ponds and swamps. *P. clarkii* culture is popular in Southern USA, particularly in Louisiana.

D) LOBSTERS

Homarus americanus (American lobster), *H. gammarus* (European lobster), *Panulirus homarus, Puerulus sewelli* (whip or spiny lobster) are the cultivated lobsters (Fig. 1-17). Lobster is one of the most highly prized of all seafoods. Lobsters have very good demand in international market. In India, *P. homarus* and *P. sewelli* are cultured in intertidal zones of seas.

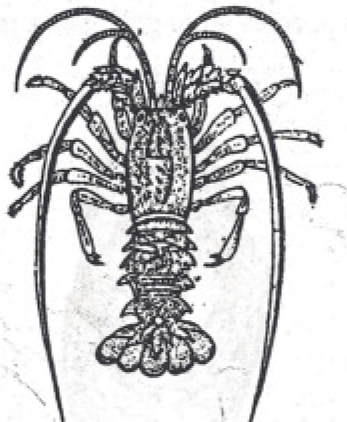


Fig. 1-17. Lobster

E) CRABS (Family Brachyura)

The important cultivable crabs are the serrated crab or mud crab or swimming crab, *Scylla serrata* (Fig. 1-18) and the green crab, *S. oceanica.* Of these, *S. serrata* is the most economical and commonly cultured in many parts of the world. In India, the culture of *S. serrata* has been carried out in brackishwater ponds under polycultue system with milkfish or penaeid shrimp as the main crop. Cages and pens are most frequently used for crab culture in several other countries. In most coastal fish ponds and impoundments in Asia, the serrated crab forms a subsidiary crop.

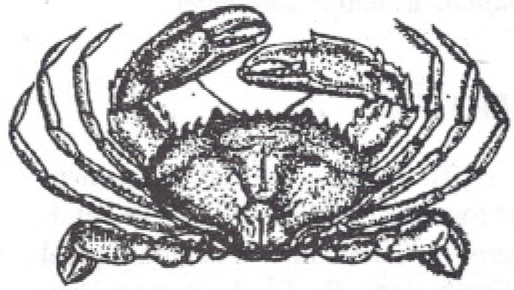


Fig. 1-18. Scylla serrata

ii) MOLLUSCS

There are several species of bivalves and a smaller number of gastropods which are cultivated. Among these the more important are the oysters (family Ostreidae), mussels (family Mytilidae and Aviculidae), clams (family Mercenaridae), scallops (family Pectinidae), the abalone (family Haliotidae) and the cockles (family Arcidae). The group that accounts for the largest production of molluscs through aquaculture is the oysters. The culture of mussels and clams is more restricted. Other species are cultured only on a small scale or are in the experimental stages.

A. OYSTERS

The edible oysters belonging to two genera, *Crassostrea* (the cupped oysters) and *Ostrea (*flat oysters) are used for culture all over the world. Some of the important cultivated species are *Crassostrea gigas* (Pacific oyster), *C. virginica* (American oyster), *C. plicatula* and *P. rivularis* (Chinese oysters) and *Ostrea edulis* (Flat oyster or European oyster). In India, *C. madrasensis* (Fig. 1-19a) has been cultured in large scale. Japanese or Indian pearl oyster, *Pinctada fucata* (Fig. 1-19b) is the most important species among the pearl producing oysters.

Fig. 1-19. a) *Crassostrea madrasensis*

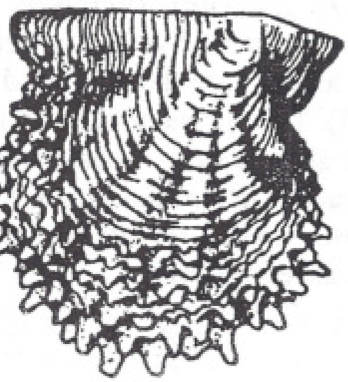


Fig. 1-19 b) *Pinctada fucata*

B. MUSSELS

The mussels of importance in aquaculture include the blue mussel *Mytilus edulis*, the Mediterranean mussel, *M. galloprovincialis*. The culture of the green mussel, *Perna viridis (= M. viridis)* has been practiced in the Philippines for several years (Fig. 1-20). The Chinese mussel culture is largely based on the blue mussel, but the green mussel and the black mussel, *M. crassitesta* are also important. The green mussel cultured in New Zealand is *P. canaliculus*, and the main species in Venezuela is *P. perna*. Experimental culture of edible mussels in India includes the brown mussel, *P. indica* and the pearl producing mussel, *Lamellidens* spp.

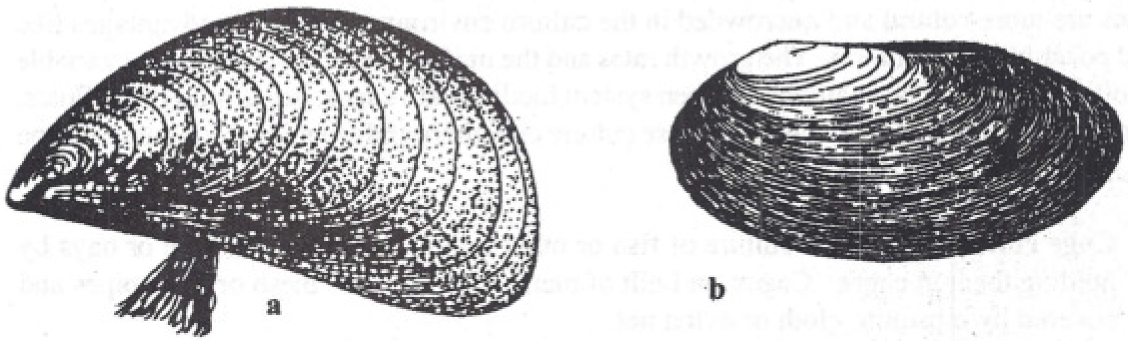


Fig. 1-20. a) *Perna viridis* b) *Lamellidens*

C. CLAMS

The species used in commercial culture are *Venerupis japonica* (Japanese little-neck; Manila clam) in Japan, Korea, the Philippines and the USA; *Meretrix meretrix* (big clam), *M. luroria* (clam) in Japan and Taiwan; *Mercenaria mercenaria* (hard clam) in the USA and *Anadara granosa* (blood cockle) in several Southeast Asian countries.

D. SCALLOPS

The most important cultivated species in Japan is the deep sea scallop or the gaint ezo scallop, *Patinopecten yessoensis*, in China, *Chlamys farreri* and *C. nobilis* and in the USA, the bay scallop, *Argopecten irradians* and the giant scallop, *Placopecten magellanicus.*

E. ABALONES

Abalones belonging to the genus *Haliotis* are the most valuable marine gastropods and probably the most sought-after molluscan seafood in many areas. The major abalone producing countries are Mexico, Japan and Australia.

1.1.5.3. SEAWEEDS

The main groups of seaweeds cultivated for human food are the following:

Red algae (Rhodophyceae) – *Porphyra* spp; Brown algae (Phaeophyceae) – *Undaria pinnatifida* and *Laminaria* spp., Green algae (Chlorophyceae) – *Entermorpha compressa and Monostroma* spp. Japan, China and Korea are the major producers of seaweeds and they grow them mainly for human consumption. Many other countries including the USA, Canada and some Caribbean Islands are now undertaking culture to produce raw material for industrial uses.

1.1.6. CULTURE SYSTEMS

Selection of proper type of culture system for any proposed aquaculture activity is a critical factor in the optimization of production and proper utilization of the available land and water supply. There are three major culture systems – open, semi-closed and closed culture systems.

A. OPEN CULTURE SYSTEMS

Natural water resources like rivers, lakes or bays can be used as culture systems. The organisms to be cultured are stocked in the culture facilities designed or constructed in the natural water body. Capital expenses are low for the open culture systems. There is less management than in the other systems. The conditions are more natural and uncrowded in the culture environment. The disadvantages like predation and poaching are common. The growth rates and the uniformity of the produce are variable compared to other systems. The examples of open system facilities are cages, pens, long lines, floats, rafts, racks and trays and clam beds. Based on these culture chambers and techniques, cultures can be designated as follows.

1. **Cage culture:** It is the culture of fish or other organisms in a river, lake or bays by holding them in cages. Cages are built of metal rods, bamboo mesh or PVC pipes and covered by mosquito cloth or nylon net.

   Cage culture, in recent years, has been considered as a highly specialized and sophisticated modern aquaculture technique, receiving attention for intensive exploitation of water bodies, especially larger in nature, all over the world. In India, cage culture was attempted for the first time in case of air breathing fishes like *H. fossilis* and *A. testudineus* in swamps.

2. **Pen culture:** Pens are the specially designed nylon or bamboo made enclosures constructed in a water body into which fish are released for culture. Such type of culture is referred to as pen culture.

3. **Raft culture:** Rafts are generally made of bamboo poles or metal rods with buoys at the top for floating in the water. These are used in the culture of oysters, mussels and seaweeds in open seas.

4. **Rack culture:** Racks are constructed in brackishwater areas and inshore areas for rearing oysters, mussels, seaweeds, etc.

B. SEMI-CLOSED CULTURE SYSTEMS

In these systems, water is taken from natural sources or ground water and is directed into specially designed ponds and raceways. These systems offer a greater control over the growing conditions. The growth rate and the crop being more uniform. Water can be filtered to remove predators, and diseases can be controlled by proper treatment. Hence, greater production per unit area is possible than in open systems.

However, these systems require much care in management and more expensive. Examples: ponds and raceways.

1. Pond Culture:

The majority of aquaculture throughout the world is conducted in ponds. Earthen ponds or reinforced concrete ponds are used for culturing the fish, shrimp, prawn, etc. in both freshwater and brackishwaters.

2. Raceway culture:

A series of earthen or cement tanks are constructed along the course of a river or stream and are used for fish culture. Raceway is a culture chamber that is generally long and narrow. Water enters at one end and leaves through the other end in most cases.

C. CLOSED CULTURE SYSTEM

In this, no water is exchanged and the water is subjected to extensive treatment. Extremely high densities of organisms may be cultured under these conditions. Complete control over the growing conditions is possible in closed systems. All the water quality parameters including temperature is regulated, diseases are not found and harvesting is simple. Food can be provided efficiently for quick growth and uniformity of crop. Fish or prawn culture in water recirculation systems is good example for closed systems.

Water recirculation systems: Here the water is conserved throughout most or all of the growing season by circulating in the culture tanks after purifying it through biological filters. Closed recirculating water systems are being used primarily for experimental work and for the rearing of larval organisms in commercial or research facilities. Closed systems are generally comprised of four components; the culture chambers, a primary settling chamber, a biological filter (biofilter) and a final clarifier or secondary settling chamber for purification of water for reuse.

1.1.7. CLASSIFICATION OF AQUACULTURE

A. Based on the environment in which the culture is done, aquaculture is of three types.

1. **Freshwater aquaculture,** where the culture takes place in freshwater bodies (salinity <0.5PPT). It includes the culture of freshwater food fishes, freshwater prawns, ornamental fishes, sport fishes and larvivorous fishes in ponds, tanks, raceways, sewage systems, etc. Freshwater fish culture in India involves cultivation of fast growing commercially important food fishes such as the Indian major carps, exotic carps, air breathing fishes, etc.

2. **Brackishwater aquaculture,** where the culture takes place in brackishwaters (Salinity 0.5 to 30 PPT). Fish such as milkfish, cock-up and mullets, and shrimps could be cultured either in brackishwater ponds (tidal ponds) or by installing bamboo or nylon enclosures, called pens. Pole culture of mussels, rack culture of oysters, and raft and rope culture of mussels are widely employed in brackishwaters. In shallow brackishwater regions, culture of the mangrove crab, *Scylla serrata* may also be attempted by constructing bamboo cages.

3. **Mariculture** (Marine aquaculture or salt water culture), where culture takes place in sea waters (salinity >30 PPT, mostly 30-35 PPT). It is carried out in *pollution free* nearshore, coastal and open sea environments. In mariculture, fish, shell-fish and sea weeds are widely cultured. Floating cages for the culture of fish, shrimp and lobsters, racks for oysters, raft and rope, pole and long lines for mussels, nets or webbings for sea weeds are at present widely employed.

   In the supersaline salt pan areas, where the salinity is more than 200 PPT, culture of brine shrimp, *Artemia salina* can be undertaken. The culture carried in supersaline waters is called **metahaline culture.** The *Artemia* has commercial value in fisheries, as their cysts (dormant eggs) earn a good foreign exchange and the nauplii hatched from the cysts serve as an instant protein- rich live food for the larvae of fish and shell-fish.

B. Based on the type of organisms cultured, aquaculture may be classified into the following sub-types.

1. **Fish culture or pisciculture or fish husbandry:** It includes the culture of true fishes of all categories such as food fish, sport fish, ornamental fish and larvivorous fish. Different types of cultivable food fishes are carps, trouts and salmons, catfishes, eels, tilapias, mullets, milkfishes, murrels, sea-basses and sea-breams, yellow tail, gouramis, etc.

2. **Shell-fish culture:** It includes the culture of **crustanceans** (shrimps, prawns, crayfish, lobsters and crabs) and **molluscs** (edible oysters, pearl oysters, mussels, clams, scallops, abalones, conches, squids and snails).

3. **Frog culture:** The species used for culture are *Rana esculenta, R.cancrivora, R.catesbeiana, R.temporaria, R.ripens, Hyla* aurea, etc. In India, *R.catesbeiana* has been tried for culture.

4. **Seaweed culture:** The important genera used for culture are *Laminaria, Undaria, Porphyra, Gracilaria, Eucheuma, Gelidium, Enteromorpha* and *Caulerpa.*

C. Based on the combination of cultivable organisms, aquaculture can be classified into three types.

1. **Monoculture:** The culture of a single species in a given culture unit (eg., pond, raceway, tank, cage or other type of culture chamber) is called monoculture. It is also called monospecies culture.

   Even the **monosex culture** is employed for the culture of males and females of a species in separate ponds inorder to enhance the growth rate and thereby increasing the yield. This type of culture is used for prolific breeders in confined waters. For example, *Tilapia* is a prolific pond breeder. If the males and females are cultured separately, the energy used for reproduction is also utilized for growth resulting in maximum production.
2. **Polyculture:** The culture of two or more species together in a pond (or any other culture unit) is called **polyculture** or **composite culture.** Here, the compatible species of different feeding habits are grown together in the same pond so that maximum utilization of food from different ecological niches is possible resulting in the maximum production per unit area of a water body.

Example:

1. The composite fish culture of Indian major carps and exotic carps in freshwater ponds is the most common practice in India.
2. Culture of Indian major carps and prawns or shrimps in ponds.
3. Culture of crabs and milk fish or penaeid shrimps in brackish water ponds.

3. Integrated fish farming: In this system, fish are cultured along with **agricultural crops** such as paddy, banana, coconut, papaya, etc. or **other animals** such as poultry, duck, cattle and pig. The excreta of livestock serve as manure for plankton production or as direct food for fish. The agricultural field (paddy) provides space for culture and the crops provide shade for the fish. The excreta of the fish inturn serve as manure for the crops.

D. Based on the levels of management intensity of a culture system, aquaculture can be categorized into five types.

1. **Traditional culture:** It is the simplest and an age old practice with little inputs and management. In traditional culture practice, the yield is very low per unit area because of low stocking density without selection of species, lack of fertilization and supplementary feeding.

2. **Extensive culture:** It is an improved culture practice over the traditional culture where the cultivable species are selected and stocked at low density. Fertilizers and supplementary feds are used to a limited extent in the fields. The stocked species mostly depend on natural food organisms developed from fertilization of water.

3. **Semi-intensive culture:** It is an improved culture practice over the extensive culture where the cultivable species are selected and stocked in the form of post larvae or fingerlings at a higher stocking density. Mostly the seed produced from hatcheries is stocked. Fertilizers to develop natural food organisms, and supplementary feed in the form of formulated compound feed as per nutritional requirement are provided. Water quality is maintained to a certain extent by the culturist.

4. **Intensive culture:** It is a highly evolved culture practice with a very high stocking density and provided with more formulated feed and more aeration. Animals are cultured with a great control by the culturist. Stocking is done with hatchery reared juveniles. Natural food is negligible in the culture system and is exclusively feed-based. Water quality is maintained by frequent changing or by providing water circulation together with constant aeration. Ponds, tanks, raceways and cages are examples of culture chambers utilized in intensive culture.

5. **Super or Hyper intensive culture:** The stocking density is extremely higher. There is a complete control of the culture system by the culturist. Continuous water exchange is made through biological filter system. Constant aeration is provided to meet the dissolved oxygen requirements at higher stocking densities. Highly nutritious pelleted feeds are provided for better growth of cultivated animals.

E. Based on the levels of input intensity, the aquaculture can be categorized into four levels.

1. **O-Level:** In this level, absolutely no management is found in culture system. No stocking, fertilization and supplementary feeding in the system. The only practice is the harvesting of wild or natural stock of fish or prawn in the pond.

2. **I-Level:** Only one management practice, i.e. stocking of seed from outside is prevalent. No fertilization and supplementary feeding in the culture system. The stocked animals depend only on the natural food organisms i.e. natural productivity alone.

3. **II-Level:** Two types of management i.e. stocking of seed and application of fertilizers are prevalent. Supplementary feed is not applied. Culture animals still depend on natural food organisms which are developed by the application of organic and inorganic fertilizers in the culture system.

4. **III-Level:** Three types of management techniques are applied in culture systems. They are – high level of seed stocking, fertilization of water and supplementary feeding. Semi-intensive, intensive and super intensive culture practices are of this type and the production is very high in contrast to the above levels. As the level of management increases, the cost of material input and human involvement also rises.

F. Based on a specific character of the environment used for culture, aquaculture is categorized into the following types.

1. **Cold-water aquaculture:** Culture of cold water fishes which are living in waters at a temperature of 10-20^{0}C is referred to as cold-water aquaculture. The upland water at high altitudes of hills and mountains, and the spring water at low altitudes in temperate regions remain cooler than any other water. In India, such waters are seen in the streams, pools and reservoirs of Himalayan mountain ranges and in the Deccan plateau of peninsular India such as Nilgiris, Kodaikanal, Munnar, etc. The species used for cold-water fish culture are the carps (*Cyprinus* spp), golden carp (*Carassius* spp.), tench (*Tinca tinca*), trouts (*Salmo* spp.) and Mahseers (*Tor* spp.).

2. **Warm-water aquaculture:** Culture of aquatic organisms in water bodies where the temperatures are above 15^{0}C is called warmwater aquaculture

3. **Upland culture:** Culture of aquatic organisms in upland water bodies is called upland culture. The hills, mountains and high altitude regions have abundant upland water bodies. They are generally free from pollution and are mainly oligotrophic with very low nutrient status on account of their catchment area being glacial drainage, inhospitable climatic conditions, rocky basins and minimum biotic interference. The waters are generally cool. On account of their limnological characteristics, these waters are generally suitable for cold water fish culture.

4. **Lowland culture:** Culture of aquatic organisms in lowland water bodies such as those in low-lying catchment areas and valleys, is referred to as lowland culture. These waters are generally

eutrophic with heavy organic nutrient loads and have undergone maximum biological degradation due to human interference.

5. **Inland culture:** The aquaculture carried out in inland water bodies (freshwater and brackishwater) is referred to as Inland culture (See Lesson 1.2).

6. **Coastal aquaculture:** Culture of aquatic organisms, especially the brackishwater fin-fish and shell-fish, in water bodies of the coastal lands including the modern pond farms constructed, or those reclaimed from unutilized coastal lands is referred to as coastal aquaculture.

7. **Estuarine culture:** Culture of brackishwater species in estuaries is called estuarine culture. Estuaries are the areas where rivers open into the sea.

1.1.8. SUMMARY

1. Aquaculture is the rearing of aquatic organisms under controlled or semi-controlled conditions. It includes the culture of fin-fish (true fishes), shell-fish (crustaceans and molluscs), echinoderms, frogs, seaweeds, etc. Aquaculture appears to be the most suitable means of increasing food production as the captures from the natural environment are getting static due to pollution and overexploitation of the wild stock. Extensive development of aquaculture by using vast aquatic resources lead to '*Blue revolution*' in the country.

2. Aquaculture has acquired a special significance because of the following reasons. It contributes not only the food resources but also several commercially important products. It gives higher production per unit area and is the most efficient among farm animals in converting feed into nutritious food i.e. having high food conversion rate. It helps in overall development of rural areas, earning foreign exchange, in recycling of animal and agricultural wastes, in sea-ranching, in converting waste lands into productive ones, in maintaining sport fishing and aquaria. Fish food is easily digestible and rich in essential amino acids and vitamins. Fish fat has easily digestible PUFA and has medicinal value.

3. Aquaculture has a long history in Asia, ancient Egypt and in central Europe. Egyptians were probably the first in the world to culture fish as far back as 2500 BC. Later it was introduced into several countries all over the world.

4. The major cultivated fishes in different parts of the world include carps, trouts, salmons, catfishes, eels, tilapias, grey mullets, milkfish, yellow tail, sea-basses, sea-breams, murrels, gouramis, groupers, turbot, sportfish, ornamental fish and larvivorous fishes.

5. The major cultivated shell-fishes include shrimps (*Penaeus* spp), prawns (*Macrobrachium* spp.), crayfishes, lobsters and crabs among crustaceans and oysters, mussels, clams, scallops and abalones among molluscs. Sea weed culture, which is of relatively recent origin and developed as large-scale farming in countries like China, Japan, Korea and Taiwan is also important.

6. Selection of proper type of culture system is a prerequisite for the optimization of production and proper utilization of the available land and water resources. There are three major culture systems: Open (e.g., cage, pen, raft and rack culture), semi-closed (e.g., pond and raceway culture) and closed (water recirculation system) culture systems.

7. Aquaculture can be classified into several types based on certain criteria such as i) the environment in which the culture is done (e.g., freshwater, brackishwater and mariculture), ii) the type of organism cultured (e.g., Fish culture or pisciculture, shell-fish culture (shrimp, prawn, oyster, mussel, etc.), frog culture and seaweed culture), iii) combination of cultivable organisms (e.g., monoculture, polyculture and integrated fish farming), iv) the levels of management intensity of a culture system (e.g., traditional, extensive, semi-intensive & intensive culture), v) the level of input intensity (e.g., O,I,II and III – level culture) and vi) a specific character of the environment used for culture (e.g., coldwater or warm-water aquaculture; upland, lowland, inland, coastal and estuarine culture).

1.1.9. GLOSSARY

Aquaculture: The rearing of aquatic organisms under controlled or semi-controlled onditions

Boifilter: The component of closed recirculating water systems in which the removal or detoxification of certain dissolved compounds occurs as a result of microbial activity. The most important reaction is nitrification of ammonia to nitrate.

Brackishwater: The intermediate type of aquatic environment where freshwater mingles with marine water.

Cage culture: Culture carried out in chambers generally constructed of wire or netting around rigid frames, floated or suspended in large water bodies such as rivers, lakes, or bays.

Closed system: The type of aquaculture system wherein the water is conserved throughout most or all of the growing season. In most instances the water is recirculated through a culture chamber, a primary setting chamber, a biofilter, and a secondary settling chamber on each pass through the system.

Culture chamber: Any vessel utilized to hold and grow aquaculture organisms. Some examples are tanks, cages, silos, ponds, and raceways.

Environment: The total of all internal and external conditions that may affect an organism or community of organisms.

Estuary: A semiclosed coastal water body with free connection with the open sea, in which seawater is diluted to some degree by freshwater.

Euryhaline: Organisms that can adapt to wide variations in salinity.

Eutrophic: Describing water bodies that contain abundant levels of nutrients, resulting in high levels of organic production. Eutrophication is an intermediate stage in lake succession and can be accelerated by activities of humans.

Extensive culture: Low intensity aquaculture such as is practiced in ponds by subsistence culturists. Extensive culture is characterized by large water areas in which low densities of culture animals are maintained, controlled to a limited extent by the culturist.

Fish Body Oil: Oil from the entire body of fish excluding liver. It is used in the manufacture of paints and varnishes, in leather and soap industry, in the manufacture of cosmetics, candles, lubricants, printing inks, linoleum, plastics, etc.

Fish Caviar: Processed and salted product of fish roe. A popular appetizing dish in Russia.

Fish glue: Prepared from fish wastes, bones and skin. It is a good adhesive and used for smearing the back side of stamps and labels, in paper box and shoe-making industries.

Fish guano: Inferior quality fish meal rich in nitrogen content (8-10%). It is a by-product of body oil extracting industries and used as effective manure.

Fish manure: Very inferior quality fish meal product obtained from spoiled fish, trash fish and fish wastes. Used in tobacco, coffee and tea plantations.

Fish meal: Powered form of the flesh and other parts of the fish. A highly nutritive product and used as poultry, cattle and fish feed.

Fish silage: A kind of liquid or semi-solid fish meal and a highly nutritive animal feed.

Intensive culture: The rearing of aquaculture organisms in extremely high densities with a great measure of control in the hands of the culturist. Tanks, raceways, silos and cages are examples of culture chambers utilized in conjunction with intensive culture systems.

Isinglass: It is a collagen derived from air bladders of some fishes. Its chief use is in clarification of beer, wine and venegar. Also used in confectionary as a substitute for gelatin.

Oligotrophic: Type of water body characterized by low levels of nutrients and low rate of production.

Open system: An aquaculture system in which water continuously flows through the culture area and is discarded after a single pass.

Open waters: A general term applied to denote running waters or any inland water body having an outlet.

Pond: Small, shallow excavated body of water widely used for inland fish culture.

Primary Settling Chamber: A unit in a closed recirculating water system in which waste feed, fecal material and other suspended particles are allowed to settle before the water flows into the biofilter.

Production: The elaboration of organic matter by the organisms in a specific area or volume over a given period.

Raceway: A culture chamber or water body that is generally long and narrow having its inlet and outlet at opposite ends.

Recruitment: Addition of individuals to population. The addition may takes place by reproduction which is related with fecundity or by immigration.

Secondary settling chamber: A chamber similar to the primary settling chamber of closed recirculating water systems but located between the biofilter and the culture chamber.

Shell-fish: Commercially important invertebrates, usually crustaceans and molluscs which have an exoskeleton or a shell (external or internal).

Sport fish: Fishes usually caught by rod and line for enjoyment or recreation. Also called game fish.

Subsistence culture: Extensive pond culture, which is simplified to the extent that individuals or small groups of people can rear aquatic organisms for their own consumption at a rate that provides a relatively continuous supply.

Supplementary food: A prepared food formulated to provide protein and other nutrients in excess of those obtained from natural food organisms in the environment.

Yield: Harvest or production of desirable species in a certain period (annual) from any given area.

1.1.10. MODEL QUESTIONS

1. What is aquaculture and give its classification.
2. Describe the history of aquaculture.
3. Discuss the culture systems used for aquaculture practices.
4. Write short notes on
   a) Significance of aquaculture
   b) Mariculture
   c) Polyculture
   d) Integrated fish farming
   e) Categories of aquaculture based on the levels of management
   f) Cultivable species of catfishes

g) Cultivable species of oysters and mussels
h) Open culture systems

1.1.11. REFERENCE BOOKS

Pillay, T.V.R. 1990. *Aquaculture Principles and Practices,* Fishing News Books Ltd., Oxford.

Stickney, R.R. 1979. *Principles of Warmwater Fish Culture,* John Wiley & Sons, Inc., New York.

Jhingran, V.G. 1991. *Fish and Fisheries of India.* Hindustan Publishing Corporation (India), Delhi.

Pandian T.J. (Ed) 2001. *Sustainable Indian Fisheries,* National Academy of Agricultural Sciences, India.

Ayyappan, S. (Ed.) 2000. Souvenir of the Fifth Indian Fisheries Forum, 17-20 January, 2000. Asian Fisheries Society, Indian branch, CIFA, Bhubaneswar.

Dr. P. PADMAVATHI

UNIT – I

LESSON - 1.2

CULTIVABLE SPECIES AND INLAND WATER BODIES SUITABLE FOR CULTURE IN INDIA

1.2.1. Objectives
1.2.2. Introduction
1.2.3. Major cultivable fin-fish and shell-fish in India
1.2.4. Inland water bodies suitable for culture in India
A. Freshwater bodies
I) Ponds and tanks
II) Swamps
III) Reservoirs
IV) Floodplain wetlands (Beels)
B. Brackishwater bodies
I) Bheries
II) Paddy fields
III) Small shallow coastal lagoons
IV) Coastal aquaculture pond farms
1.2.5. Summary
1.2.6. Glossary
1.2.7. Model Questions
1.2.8. Reference Books

1.2.1. OBJECTIVES

The purpose of this lesson is

* to know the cultivable aquatic organisms in India and the culture potential of major fin-fish and shell-fish in freshwater and brackishwater aquaculture, and
* to understand the inland water bodies suitable for culture in India along with their extent, description and culture activities.

1.2.2. INTRODUCTION

The vast resources in terms of water bodies and species of fin-fish and shell-fish in different agro-ecological regions of the country provide for a wide array of culture systems and practices. There are several species of fin-fish, shell-fish and plants that are used in experimental or commercial aquaculture. But the bulk of present day production is based on a small number of species. Carps, catfishes, prawns and shrimps form important components of culture organisms in the country. In terms of cultivable species of fish/shell-fish, the components are diverse to suit varied ecological conditions of different water bodies so as to meet the regional preferences.

1.2.3. MAJOR CULTIVABLE FIN-FISH AND SHELL-FISH IN INDIA

India being basically a carp producing country, the indigenous and exotic carps, *viz*, catla (*Catla catla*) rohu (*Labeo rohita)*, mrigal (*Cirrhinus mrigala)*, silver carp (*Hypophthalmichthys molitrix)*, grass carp (*Ctenopharyngodon idella)* and common carp (*Cyprinus carpio)* account for bulk of the production, being as much as 82% of the total aquaculture production. The country also has several other potential candidate species of medium carps, such as *Labeo calbasu, L. fimbriatus, L. gonius, Puntius pulchellus, P. kolus, P. sarana* and *Cirrhinus cirrhosa.* Even the minor carps like *L. bata* and *Amblypharyngodon mola* also fetch very high price in the north-eastern parts of the country. Recently, the freshwater aquaculture activities have been more diversified with pond farming of catfish and freshwater prawns.

Catfishes in India constitute considerable fishery of commercial value in large rivers and reservoirs. While several large non-air breathing catfishes such as *Wallago attu, Mystus seenghala, M. aor, Pangasius pangasius, Rita pavimentata* are in great demand in the north and north western states, the smaller varieties of both air-breathing (*Clarias batrachus, Heteropneustes fossilis)* and non-air breathing catfishes (*Ompok bimaculatus, O. pabda)* are considered a delicacy in the eastern and north eastern states. Among the catfishes that command high market value, the Asian catfish, *C. batrachus* is of utmost importance. Though catfishes have great consumer preference, their culture systems are yet to be established in many countries of Asia including India. However, the air-breathing catfishes, *Clarias batrachus* and *Heteropneustes fossilis* command a good market value and the most preferred fish in some states of the country, and a large number of farmers are evincing interest in taking up their culture.

While the above catfishes are native to India, there are a few exotic varieties which are in good demand to-day in most of Southeast Asian countries. They are *Clarias macrocephalus* which closely resembles *C. batrachus* in its shape, size and colour as also perhaps the taste, and the carnivorous variety, the African catfish, *Clarias gariepinus* which grows to huge sizes (above 1.5 m/10 kg). Then comes the most important one, *Pangasius sutchi* which is believed to taste better than the native *P. pangasius*. This has already found its entry into our country and they are being cultured in some private fish farms in West Bengal, Orissa and Andhra Pradesh. Similarly, the American channel catfish *Ictalurus* sp. also has drawn the interest of some entrepreneurs who tried to develop its culture with limited success.

Murrels (*Channa marulius, C. punctatus, C. striatus)* are also potential species for culture. The country also possesses two important freshwater prawn species, *viz*., *Macrobrachium rosenbergii* and *M. malcolmsonii*, which have already received attention of farmers and entrepreneurs for establishing hatchery and their grow-out production. Molluscan culture is gaining emphasis in the context of production of cultured freshwater pearls through nuclear implantation in the bivalve, *Lamellidens* spp.

In brackishwater aquaculture, several species of shrimps (*Penaeus monodon, P. indicus, P. penicillatus, P. merguiensis* and *Metapenaeus* spp.) fishes (*Mugil cephalus, Liza parsia, L. macrolepis, L. tade, Chanos chanos, Lates calcarifer, Etroplus suratensis and Epinephelus tauvina)* and crabs

(*Scylla serrata and S. tranquebarica)* have the potential for farming. However, large scale farming is restricted to *P. monodon and P. indicus.*

1.2.4. INLAND WATER BODIES SUITABLE FOR CULTURE IN INDIA

India is endowed with vast and varied aquatic resources (marine and Inland) amenable for capture fisheries and aquaculture. While the marine water bodies are used mainly for capture fisheries resources, the inland water bodies are widely used both for culture and capture fisheries. Most of the inland water bodies are captive ecosystems where intensive human intervention in the biological production process can be possible and thereby holding enormous potential for many fold increase in fish output. *Inland water bodies* include *freshwater bodies* like rivers, canals, streams, lakes, flood plain wetlands or beels (ox-bow lakes, back swamps, etc.), reservoirs, ponds, tanks and other derelict water bodies, and *brackish water areas* like estuaries and associated coastal ponds, lagoons (Chilka lake, Pulicat lake) and backwaters (vembanad backwaters), wetlands (bheries), mangrove swamps, etc., The inland water resources available in India are given in Table-1.

Table-1. Inland water resources in India

Resource	Extent	Type of fisheries
a. Rivers	29,000 km	capture fisheries
b. Canals & streams	1,42,000 km	capture fisheries
c. Lakes	0.72 m ha	capture fisheries
d. Reservoirs	3.152 m ha	
Large	1,140,268 ha	capture fisheries
Medium	527,541 ha	capture fisheries
Small	1,485,557 ha	culture-based fisheries
e. Ponds & tanks	2.85 m ha	culture fisheries
f. Flood plain wetlands (Beels / Ox-bow lakes)	202,213 ha	culture-based fisheries
g. Swamps and Derelict waters	53,471 ha	Nil (not known)
h. Upland lakes	720,000 ha	Not known
i. Brackish water	2.7 m ha	
Estuaries	300,000 ha	capture fisheries
Back waters	48,000 ha	capture fisheries
Lagoons	140,000 ha	capture fisheries
Wetlands (Bheries)	42,600 ha	culture fisheries
Mangroves	356,000 ha	subsistence
Coastal lands for aquaculture	1.42, m ha	culture fisheries

m ha – million hectares

Of these, the rivers, canals, streams, lakes, large and medium reservoirs, estuaries, and associated backwaters and lagoons support the capture fisheries. Whereas freshwater ponds, tanks, swamps and estuarine wetlands (bheries), paddy fields, small shallow coastal lagoons and coastal pond farms support the culture fisheries or aquaculture.

In capture fisheries, the wild populations are simply harvested from the natural waters with little human intervention in modifying the ecosystem i.e. hunting. Example: marine fishery. On the other hand, in a culture fishery, the whole operation is based on captive stocks with a high degree of effective human control over the water quality and other habitat variables. Example: Culture of fish and shell-fish in ponds. When the fish harvest in an open water system depends solely or mainly on artificial recruitment (stocking), it is generally referred to as culture-based fisheries. Culture-based fishery is the most common method of enhancing the fish production being followed in some inland water bodies in India.

The inland water bodies which are used for culture and culture-based fisheries are detailed hereunder.

1.2.4. A. FRESHWATER BODIES

I) PONDS AND TANKS

There are innumerable ponds and tanks of different size, both perennial and seasonal.. With the rapid development of aquaculture in the last two decades, the ponds have been increasing tremendously. Not only the waste and low-lying lands but also the vast tracts of agricultural land are being converted to myriads of fish ponds. The area under ponds and tanks available for freshwater aquaculture in India has been estimated at 2.85 m ha. Ponds and tanks are more numerous in West Bengal, Andhra Pradesh, Bihar, Orissa and Tamilnadu. The ponds offer scope for enhanced productivity through semi-intensive and intensive aquacultural practices. Indian freshwater aquaculture has evolved from the stage of a domestic activity in West Bengal and Orissa to that of an industry in recent years, with states like Andhra Pradesh, Haryana, Maharashtra, etc., taking up fish culture as a trade. With technological inputs, entrepreneurial initiatives and financial investments, pond productivity has gone up from 600-800 kg/ha/yr to over 8-10 tonnes/ha/year. While carps (Indian and exotic) are the main species cultured in ponds, others like catfishes, murrels, freshwater prawns and molluscs for pearl culture are also being cultured in ponds.

II) SWAMPS

In India an estimated 0.6 million ha of water remains unutilized for fish production. This is in the form of marshes and swamps alone. Reclamation of such swamps into fish ponds is recognized as an effective means of making them productive but difficult for fish culture from production standpoint. However, these can be made productive with the introduction of cage-culture of air breathing fishes. The success is largely due to the fact that the two main obstacles of swamp can be overcome by this. Cage culture precludes all risks of cultured fish being lost during harvesting in these weed infested waters. Secondly, selection of air-breathing species of fish eliminates the danger of mass kill under conditions of deoxygenation. A number of air-breathing fishes are indigenous to our waters, and many of these are popular as food fishes among the Indians. The important ones are: magur (*Clarias batrachus*), singhi (*Heteropneustes* fossilis), koi (*Anabas testudineus*), murrel (*Ophiocephalus* (=*Channa)* spp.*)* and chital (*Notopterus* spp*)*. An exotic fish, gourami (*Osphronemus gorami*) is also equally valuable for cultivation in swamps.

III) RESERVOIRS

Reservoirs are defined as "man-made impoundments created by erecting a dam of any description on a river, stream or any water course to obstruct the surface flow". However, water bodies less than 10 ha in area have been excluded from this definition. The Ministry of Agriculture, Government of India classified reservoirs as small (<1000 ha), medium (1000 to 5000 ha) and large (>5000 ha) for the purpose of fishery management. Reservoirs constitute the single largest inland fisheries resource in terms of resource size and production potential. It has been estimated that India has 19,134 small reservoirs with a total water surface area of 1,485,557 ha, 180 medium reservoirs with 527,541 ha and 56 large reservoirs with 1,140,268 ha. Thus, the country has 19,370 reservoirs covering 3,153,366 ha.

The medium and large reservoirs are predominantly capture systems. Although many of them are stocked, their fisheries continue to depend, to a large extent on the wild or naturalized fish stock. Conversely, small reservoirs are managed as culture-based fisheries, where the fish catch depends on stocking. More than 70% of the small reservoirs in India are small irrigation impoundments created to store stream water for irrigation. They either dry up completely or retain very little water during summer, thus ruling out any possibility of retaining broodstock for recruitment. Thus, culture-based fishery is the most appropriate management option for the small reservoirs in India. The key management parameters of culture-based fishery are species selection, stocking and environmental enhancement (enriching the water quality through artificial eutrophication).

Today, most of the states being capable of producing carp seed through hypophysation and the culture-based fisheries of small reservoirs in India largely center round the three species of Indian major carps *viz*., *Catla catla, Labeo rohita* and *Cirrhinus mrigala*. The Indian major carps have an impressive growth rate and their feeding habits are suitable for utilization of various food niches. In addition, the stocking of many exotic species (Tilapia, common carp, silver carp, grass carp) have also contributed substantially to commercial fisheries. The other groups having countrywide distribution are the catfishes, featherbacks, air-breathing fishes and the minnows.

IV. FLOODPLAIN WETLANDS

The floodplains are either permanent or temporary water bodies associated with rivers that constantly shift their beds especially in the potamon regimes. The Ramsar Convention defines wetlands as "areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water which is static or flowing, fresh, brackish or salt including areas of marine waters, the depth of which at low tide does not exceed nine meters".

The *beels*, or floodplain wetlands usually represent the lentic component of floodplains *viz.*, ox-bow lakes, sloughs, meander scroll depressions, residual channels and the back swamps and excludes the lotic component (the main river channels, the levee region and the flats). In addition, tectonic depressions located in river basins are also included under beels. Thus, all the wetland formations located at the floodplains can be termed as floodplain wetlands (*beels*). They are either shallow depressions or dead riverbeds generally connected to the principal rivers and/or receive backflow water from the rivers during floods or from the huge catchment area following monsoon rains.

Floodplain wetlands or lakes (202,213 ha) which form an integral component of the Ganga and the Brahmaputra basins. They constitute an important fishery resource in Assam (100,000 ha), West Bengal (42,500 ha), Bihar (40,000 ha) Manipur (16,500 ha), Arunachal Pradesh (2,500ha) Tripura (500 ha) and Meghalaya (213 ha).

Beels offer tremendous scope for expanding both capture and culture fisheries. They have high biological productivity. However, in many beels, the nutrients are usually locked up in the form of large aquatic plants like water hyacinth, and do not contribute significantly to fish production. The beels are considered as biologically sensitive habitats as they play a vital role in the recruitment of fish populations in the riverine ecosystem and provide excellent nursery grounds for several fish species, besides a host of other fauna and flora. The beels also provide an ideal habitat for pen and cage culture operations. If managed along scientific lines, fish production in beels can be increased significantly.

Beels are of two types *viz.*, closed and open beels based on the water residence and renewal time as well as the extent of macrophyte infestation. The open beels are those which retain their riverine connection for a reasonably long time and relatively free from weed infestations. The management strategy is essentially akin to riverine capture fisheries. The closed beels are those with a very brief period of connection with the river is more like small reservoirs. The basic strategy here will be stocking and recapture of fish i.e. culture-based fishery.

Beels are systems, which combine the norms of capture and culture fisheries. The marginal areas of beels are cordoned off for culture systems either as ponds or as pens and the central portion is left for capture fisheries (Fig. 1-21). Beels can also be part of an integrated system including navigation, bird sanctuary, post harvest, aquaculture and open water fisheries. A proposed scheme of closed beel (Fig. 1-22) has been shown as an example. This plan is a part of holistic development of the wetland, which can benefit the local people and help retaining the biodiversity of the beel and its environment. Pen and cage culture of fish and prawn is a very useful option for yield enhancement in beels especially those infested with weeds. Pens are barricades erected on the periphery of beels to cordon off a portion of the water body to keep captive stock of fish and prawn. Pen culture offers scope for utilizing all available water resources, optimal utilization of fish food organisms for growth and complete harvest of the stock. Pen culture involving major carps has indicated a production possibility upto 4 t/ha in 6 months from a 'maun' in Gandak basin while production varying from 1.9 to 4.8 kg have been obtained from 2 sq.km cages in 90 days from a weed choked Assam beels by rearing air-breathing fishes, *Clarias batrachus* and *Heteropneustes fossilis.*

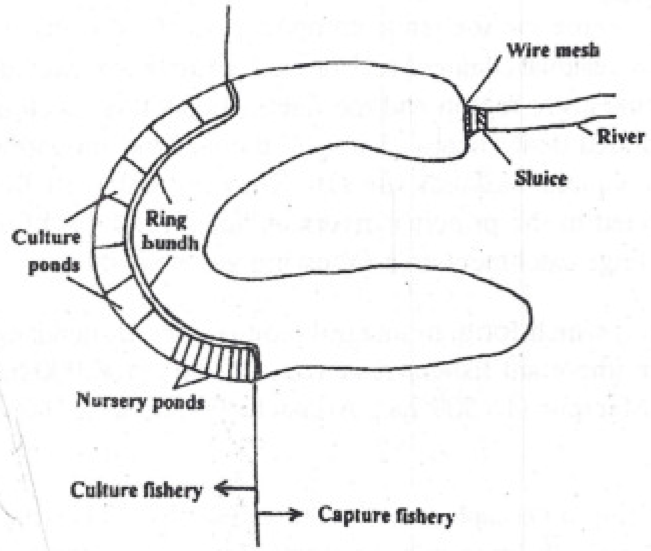


Fig. 1-21. Diagrammatic representation of culture-cum-capture fisheries

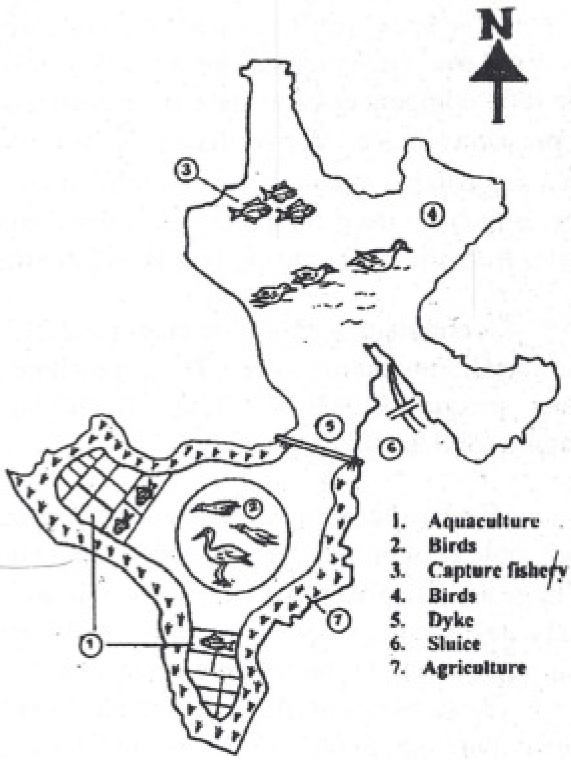


Fig. 1-22. Integrated development of Beloon *Beel*

Beels are the ideal water bodies for practising culture-based fisheries for many reasons. Firstly, they are very rich in nutrients and fish food organisms, which enable the stocked fishes to grow faster to support a fishery. Thus, the growth is achieved at a faster rate compared to reservoirs. Secondly, the beels allow higher stocking density by virtue of their better growth performance and high yield. Thirdly, there are no irrigation canals and spill ways as in the case of small reservoirs which cause the stock loss, and the lack of effective river connection prevents entry of unwanted stock. The beels also allow stocking of detrivores as the energy transfer takes place through the detritus chain.

1.2.4. B. BRACKISH WATER BODIES

India is estimated to possess along its coast a total area of 2 million ha suitable for brackishwater fish farming. But the total area under cultivation was only 65,100 ha in 1990-91, which increased to 141,837 ha in 1998-99 by the construction of coastal aquafarms as the demand for shrimps increased tremendously in the international market. Presently, brackishwater aquaculture is restricted to shrimp farming in farm ponds owing to the high export potential of penaeid shrimps (*Penaeus monodon* and *P. indicus*). The Sunderbans of West Bengal and the extensive backwaters of Kerala, where certain amount of brackishwater culture already exists, and other areas along the coasts of Bay of Bengal and the Arabian Sea are suitable for development of coastal aquaculture. The *bheri* fish culture of West Bengal, the shrimp culture in paddy fields of Kerala and culture of fish in lagoons are the three principal types of traditional fish culture practised in India. The modern brackishwater farming in coastal aquafarms assumes considerable importance in recent times.

I. BHERIES (Impoundments)

Brackishwater fish culture in impoundments comprises cultivation of fish in tidal waters admitted through sluices in suitably embanked enclosures. These are called *bhasabadha fisheries* or *bheries* in Bengal. Bheries are compounded low-lying areas in deltaic West Bengal adjacent to estuaries and creeks where culture is carried out round the year in a traditional way. The size of such bheries varies from 3 to 260 ha. Their numbers have been estimated at 1,392 together constituting an area of 42,600 ha in three brackishwater zones, *viz*., low saline (0.15-9.5 PPT), medium saline (0.27-15.8 PPT) and high saline (6.6-36.2PPT) zones. In saline bheries, the important fishes, shrimps and crabs generally cultured are: a) fishes – *Lates calcarifer, Mugil parsia, M. tade, M. speigleri, Rhinomugil corsula, Mystus gulio, Polynemus tetradactylus, Anguilla bengalensis, Scalophagus argus, Glossogobius giuris;* b) shrimps – *Penaeus monodon, P. indicus, Metapenaeus monoceros, M. brevicornis, M. rosenbergii, M. rude, Palaemon styliferus, Acetes sp., Parapenaeopsis* spp. and c) crabs – *Scylla serrata.*

In non-saline bheries, stock management and fertilization with sewage are the key concepts in fishery management. Around 170 bheries covering about 8000 ha area receives sewage in different concentrations and utilize these organic wastes for fish production. Indian major carps, exotic carps in addition to tilapia form the desired species in bheries.

II. PADDY FIELDS

The seasonal utilization of paddy fields for culture of brackishwater shrimps and fishes is quite common in West Bengal and Kerala. The practice followed in West Bengal involves the use of irrigation canal, if any, lying in the vicinity of paddy fields through which fish fry are allowed to enter the fields where they grow during the paddy cultivation period. The fish are cropped just before the harvesting of paddy. The important species of fish and shrimps cultured in the paddy fields are: Fish – *Mugil parsia, M. tade, Rhinomugil corsula, Lates calcarifer* and *Mystus gulio* and shrimps – *Palaemon carcinus, Macrobrachium rude, Metapenaus monoceros, M. brevicornis and Penaeus semisulcatus.* In recent years, *Penaeus monodon* is also introduced as a supplementary stock.

In Kerala, the brackishwater fish culture is practised in the low-lying paddy fields called *pokkali fields*. Paddy is cultivated from July to September when the surrounding back waters are low in salinity and from October, shrimp culture is practised in these fields. In the pokkali fields, shrimps constitute about 80% of the catch, the species being *Penaeus indicus, P. semisulcatus Metapenaeus monoceros, M. dobsoni, Macrobrachium rude, Palaemon styliferus, Caridina gracilirostris* and *Acetes* sp. The rest of the crop comprises mullets, pearlspots and chromides (*Etroplus maculatus*).

III. SMALL SHALLOW COASTAL LAGOONS

In the coastal south-east India, there are several small low-lying lagoons which remain disconnected with sea for major part of the year. These lagoons are said to be poor in biological productivity owing to several basic causative factors such as poor quality of soil, meager organic content, low nutrient level and hypersaline conditions persisting over greater part of the year. These water bodies can be utilized for fish culture by taking certain measures. The selected lagoon can be periodically inundated during the monsoon, establishing temporary connections with the sea. The flow of water in these ponds was controlled by means of sluices. So far, *Chanos* culture has been practising in these lagoons.

IV. COASTAL AQUACULTURE POND FARMS

Coastal aquaculture is an old established practice in several countries of Asia. Modern coastal aquaculture farms generally run as self-contained units with their complex of nursery, rearing and stocking ponds. Commercially important shrimps and brackishwater fishes have been cultured in these ponds. Vast stretches of coastal lands where suitable water available through creeks or estuaries are being converted to shrimp culture farms in recent years because of the lucrative price for shrimps in international market.

1.2.5. SUMMARY

1. The aquatic resources of our country are rich in terms of both water bodies and species of fish and shell-fish. Of the several aquatic organisms, carps, catfishes, prawns and shrimps are the important groups cultured in India. However, the bulk of present-day production is based on small number of species.

2. In freshwater aquaculture, the Indian major carps and Chinese carps (catla, rohu, mrigal, silver carp, grass carp) account for the bulk production of about 82% of the total aquaculture production. Next in culture importance are the freshwater prawns (*Macrobrachium rosenbergii* and *M. malcolmsonii*) and catfishes (*Clarias batrachus* and *Heteropneustes fossilis).*

3. In brackishwater aquaculture, among several potential species of shrimps, fishes and crabs for culture, the shrimps, *Penaeus monodon* and *P. indicus* account for the large scale farming and production in India.

4. The inland water bodies are vast and varied, which include *freshwater bodies* like rivers, canals, streams, lakes, floodplain wetlands, reservoirs, ponds, tanks and other derelict water bodies, and *brackishwater bodies* like estuaries and associated coastal ponds, lagoons, back waters, bheries, mangrove swamps, etc. The inland water bodies are used for culture and capture fisheries.

5. The inland water bodies used for aquaculture are the freshwater ponds, tanks, swamps, estuarine wetlands (bheries), paddy fields, small shallow coastal lagoons and coastal farm ponds. Beels and small reservoirs are ideal for practising culture-based fisheries.

6. Of all the inland water bodies suitable for culture, the freshwater ponds and brackishwater coastal ponds are extensively used for culture and account for the major contribution of aquaculture production.

1.2.6. GLOSSARY

Air-breathing fish: Fish possessing accessory respiratory organ that enables them to take atmospheric oxygen when required.

Beel: A Kind of derelict or semi-derelict wetlands usually formed either by tectonic activities or fluvial actions of rivers. This type of shallow, wide and weed infested water body may or may not have connections with a river.

Capture fishery: Fishing activities in open water such as river, lake ocean, etc.

Detritus: Finely divided suspended organic debris from decomposing plants and animals.

Inland water body: A water body which is enclosed partially or completely by the land.

Lentic: Designates standing water (eg., Lakes or ponds)

Lotic: Describing a flowing water environment (e.g., a stream of river)

Stream: A fast flowing perennial or seasonal water body with gravel bed. Streams are generally not very wide.

Swamp: Highly weed infested marshy area

Trophic Level: The position of an organism occupies in the food web (e.g., herbivore, omnivore, or carnivore).

Wetland: Marshy or swampy area, usually highly productive.

1.2.7. MODEL QUESTIONS

1. Give an account of the inland water bodies suitable for culture in India.
2. Write about the culture potential of major cultivated species in India.
3. Write notes on
   a) Cultivated carps in India
   b) Potential species of catfishes for culture in India
   c) Common cultivated brackishwater fish and shell-fish in India
   d) Beels
   e) Coastal aquaculture ponds
   f) Bheries

1.2.8. REFERENCE BOOKS

Jhingran, V.G. 1991. *Fish and Fisheries of India.* Hindustan Publishing Corporation (India), Delhi.

Pandian, T.J. (Ed.) 2001. *Sustainable Indian Fisheries,* National Academy of Agricultural Sciences, India.

Ayyapan, S (Ed.) 2000. *Souvenir of the Fifth Indian Fisheries Forum,* 17-20 January, 2000. Asian Fisheries Society, Indian branch, CIFA, Bhubaneswar.

Dr. P. PADMAVATHI

UNIT – I

LESSON - 1.3

CRITERIA FOR THE SELECTION OF A SPECIES FOR CULTURE

1.3.1. Objectives
1.3.2. Introduction
1.3.3. Criteria for selection
1.3.4. Summary
1.3.5. Glossary
1.3.6. Model Questions
1.3.7. Reference Books

1.3.1. OBJECTIVES

The purpose of this lesson is

* to discuss the suitability of a species for culture based on the biological characteristics, and economic and market considerations.

1.3.2. INTRODUCTION

The aim of aquaculture is to get maximum production of aquatic organisms per unit area. Though several species of aquatic organisms are available, only a few species are suitable for culture in fresh and brackishwaters. The success of a culture depends mainly on the selection of a suitable species. Generally species have to be selected according to the objectives of culture, for example, increasing protein supplies to the poor, export to earn foreign exchange or waste recycling in a polyculture system. Selection of species for culture is chiefly based on certain criteria.

1.3.3. CRITERIA FOR SELECTION

1. Ecological adaptability: Species that are hardy and can tolerate unfavourable conditions will have the advantage of better survival in relatively poor environmental conditions that may occur occasionally during culture period. The species should have the ability to withstand the fluctuations of environmental parameters such as temperature, oxygen content, p^H, salinity etc., in ponds or other enclosures where deterioration of water quality may sometimes occur unavoidably. In such situations, hardier species will obviously fare better.

2. Ability to grow fast: A major characteristic that determines the suitability of a species for aquaculture is the rate of growth and production under culture conditions. The species should be of fast growing type to reach the marketable size in a shorter time so that more frequent harvests are possible. Although certain slow-growing species may be candidates for culture because of their market value, it is often difficult to make their culture economical.

3. Availability of stocking material: Availability of seed is an important criterion for the selection of a species for culture. In cases where controlled breeding techniques have not been perfected, the aquaculturist may have to depend on seed available from the wild. The success of any culture depends on the constant supply of seed in adequate quantity. Hence it is better to select a species of regional and seasonal predominance.

4. Compatibility with other species: The species should be companiable and compatible with other species selected for polyculture. Hence, species having different feeding habits and behaviour should be selected to avoid serious competition among the different species.

5. Tolerance to crowded conditions: In intensive and semi-intensive culture, dense populations are confined in a limited space. In such cases, behaviour patterns of species in confinement are of special significance. Increase in transmission of disease, cannibalism in the early stages and accumulation of waste products are related to overcrowding. Species that have better resistance to such unfavourable conditions are better candidates for culture.

6. Heribivorous or Omnivorous feeding habit: The species low in the food chain such as herbivores or omnivores are preferable for the production of low-priced products rather than the carnivores. In modern aquaculture, feeding is one of the major elements of cost of production and may amount to 50 per cent or more. In traditional aquaculture practices, herbivorous or omnivorous species have been preferred as they feed on natural food organisms in water. The growth of food organisms can be enhanced through fertilization and water management in a cheaper way so that the cost of feeding and in turn the cost of production of fish can be minimized. However, in intensive culture systems, even with such species, supplementary feeding with artificial feedstuffs has to be adopted for better growth.

The feed efficiency in relation to growth and productivity then becomes an important criterion. Some of the low tropic level feeders can also be highly selective in their feeding habits, as in the case of filter-feeders that require plankton of a particular size and shape. The need to grow the species to market size within a limited period often makes it necessary to resort to artificial feeding.

Carnivorous species generally need a high protein diet and are therefore considered to be more expensive to produce, even though the costs will depend largely on local availability and price of the required feedstuffs. To compensate for feeding costs, most carnivorous species command higher market prices. Such species generally have greater export markets and therefore attract substantial investments.

7. Ability to accept supplementary food: The species should accept and utilize the supplementary or artificial feed provided. Even in hatcheries, the larvae that would accept artificial feeds would be easier to rear because raising of live foods is comparatively more difficult and often expensive.

8. High food conversion efficiency: There should be high food conversion efficiency (conversion of feed to flesh) among the selected varieties.

9. High flesh to bone ratio: The species should have high flesh to bone ratio. Preferably the fish should have a high body with thick back but with small head.

10. Maturity: The size and age at first maturity is also an important consideration, as it will be preferable to have them reach marketable size before they attain first maturity, so that most of the feed and energy are used for somatic growth. Early maturity would ensure easier availability of breeders for hatchery operations, but early maturity before the species reaches marketable size will also be a great handicap, as in the case of tilapia species.

11. Able to breed by Induced breeding techniques: It is preferable to culture a species that can be bred easily under captive conditions especially by induced breeding. This would permit hatchery production of reliable seed in adequate quantities. This hatchery produced seed has immense importance in large-scale farming as the natural seed collections proved to be an unreliable in terms of quality and quantity. If a species spawns more than once a year, it should be possible to have several crops of seed and possibly adults, if other conditions are suitable.

12. High fecundity: The species having high fecundity and frequency of spawning is more advantageous for culture. However, small-sized eggs and small larvae make hatching operations more difficult.

13. Good Survival rate: The species should have high percentage of survival of all stages of life i.e. eggs, larvae, juveniles and adults. A shorter incubation period of eggs and larval cycle often contribute to lower mortality of larvae and greater survival in hatcheries.

14. Resistant to diseases: The species should be hard and resistant to various diseases.

15. Consumer preference: The species should be palatable with high nutritive value.

16. Market/sale value: Economic considerations are as important or even more important to an aquaculturist than biological factors in the selection of a species for culture. Consumer acceptance and availability of markets (local or export) for the species are very intimately interlinked with the economics of raising them (i.e. the cost of production, etc.). Unless new or improved markets are developed, the culture will not flourish.

No single species will fulfill all the requirements of selection. But such species which possess the maximum desirable qualities are selected for culture. In this regard, the Indian major carps, exotic carps, tilapia, some catfishes, prawns and shrimps have many of the above features suitable to Indian conditions. Hence they are largely employed in fish culture in our country.

1.3.4. SUMMARY

1. The success of a culture depends mainly on the selection of a suitable species for culture. Of the several species of aquatic organisms available, only a few species are suitable for culture.

2. The suitability of a species for culture depends on certain biological characters it possesses and its economic and market considerations.

3. The biological characteristics on which the selection of a species for culture depends are i) Ecological adaptability ii) ability to grow fast iii) availability of stocking material iv) compatibility with other species v) tolerance to crowded conditions vi) herbivorous or omnivorous feeding habit vii) ability to accept supplementary food viii) having high food conversion efficiency ix) high flesh to bone ratio x) late maturity xi) able to breed easily by induced breeding techniques xii) high fecundity xiii) good survival rate xiv) resistant to diseases xv) consumer preference and xvi) good local or export market value.

4. Market and economic considerations are as equally important as biological factors in the selection of a species for culture. The cost of production should preferably be at its minimum. Besides consumer preference, the species should have good local or export market value. Otherwise the culture will not be economically feasible.

1.3.5. GLOSSARY

Artificial food: A prepared food formulated to provide protein and other nutrients in excess of those obtained from natural food organisms in the environment.

Carnivore: An animal that feeds exclusively on the tissues of other animals.

Fecundity: The number of mature eggs produced annually by a female animal or per unit body weight of a female.

Feeding Habit: Characteristic behaviour of a fish while taking or searching its food.

Food chain: A sequence of organisms, each of which provides food for the next, from primary producers to ultimate consumers, or top carnivores.

Food conversion efficiency: The reciprocal of food conversion ratio times 100, expressed as a percentage.

Food conversion ratio: In aquaculture, the amount of food fed divided by weight gain. The lower the FCR, the more efficient the animal is at converting feed into new tissue.

Herbivore: Any animal that feeds exclusively on plant material.

Omnivore: An animal that consumes both plant and animal material in its normal diet.

Natural food: The normal food of an organism in a natural condition.

Plankton: Tiny, microscopic aquatic plants or animals which drift at the mercy of water currents.

Supplementary food: Artificial food or natural food organisms to besupplemented in addition to the natural food available in the environment.

Survival rate: Number of fish alive after a specific period of time expressed as percentage of the initial number stocked.

1.3.6. MODEL QUESTIONS

1. Give an account of the criteria for the selection of a species for culture.
2. Discuss the biological characteristics of a species suitable for culture.

1.3.8. REFERENCES BOOKS

Pillay, T.V.R., 1990. *Aquaculture Principles and Practices*, Fishing News Books Ltd., Oxford.

Bardach, J.E., J.H. Ryther and W.O. McLarney. 1972. *Aquaculture*, Wiey – Interscience, New York.

Huet, J. 1986. *A Text Book of Fish Culture*. Fishing News Books, Oxford.

Jhingran, V.G. 1991. *Fish and Fisheries of India*. Hindustan Publishing Corporation (India) Delhi.

Dr. P. PADMAVATHI

UNIT – I

LESSON - 1.4

PROCUREMENT OF CARP SEED FROM NATURAL WATERS

1.4.1. Objectives
1.4.2. Introduction
1.4.3. Major river systems and their seed resources
  i. The Ganga river system
  ii. The Brahmaputra river system
  iii. The Indus river system
  iv. The East coast river system
  v. The West coast river system
1.4.4. Site selection for seed collection
1.4.5. Gears used for seed collection
1.4.6. Methods of seed collection
  i. Egg collection
  ii. Spawn collection
  iii. Fry and fingerling collection
1.4.7. Summary
1.4.8. Glossary
1.4.9. Model questions
1.4.10. Reference books

1.4.1. OBJECTIVES

The purpose of this lesson is

* to explain the importance of carp seed collection and the seed resources of natural waters i.e. the five major river systems of India, and
* to describe the collection sites, nets and the methods used for the collection of carp seed for stocking in culture ponds.

1.4.2. INTRODUCTION

Procurement of fish seed for stocking is an important step in fish culture practice. Early stages of fish such as egg, spawn, fry and fingerlings are termed as fish seed. Fish seed can be obtained either by collection from natural resources or by artificial production through induced breeding. Although great success has been achieved in the technique of induced breeding of major carps, collection from rivers is still popular and so continued. The natural sources of fish seed are the natural breeding grounds and the adjoining areas.

On the basis of their breeding habits the cultivable species of India may be divided into three groups namely, 1. Fish that breed in ponds (Common carp, Tilapia, Gourami, *Etroplus, Channa,* etc.) 2. Fish that breed in flooded rivers and the adjoining low lying areas (major carps, grass carp, silver carp, etc.) and 3. Fish that breed in the marine, estuarine or brackishwater zones (*Chanos, Lates, Mugil,* etc.). Thus the riverine sources constitute the natural resources for carp seed. Large scale natural spawning of carps occurs in flooded sections of rivers during the south-west monsoon months. In some rivers of Peninsular India they are reported to breed during north-east monsoon as well. Spawning grounds are located in the middle reaches of rivers where flood water inundates vast adjoining riparian lands.

1.4.3. MAJOR RIVER SYSTEMS AND THEIR SEED RESOURCES

India has five major river systems (Fig.2.1). These are: the Ganga river system, the Brahmaputra river system, the Indus river system, the East coast river system and the West coast river system.

The different river systems of India display variations with regard to the distribution and abundance of their fish fauna. This is mainly due to their individual ecological conditions such as gradient, terrain, flow, depth, temperature, substrata, etc. The rivers of the north, originating from the Himalayan glaciers and snows, are perennial and support a rich commercial fishery in the plains where the gradient is low, and shelters and deep pools abound. Of the three river systems, Ganga, Brahmaputra and Indus, the Ganga river system is the largest and contains the richest freshwater fish fauna in India. The rivers of Peninsular India, divisible into two groups – the East coast and the West coast river systems, differ from those of the north not only in that they flow through deep gorges, thick forests and inaccessible terrain, but also in respect of their fauna and its abundance. Except for the deltaic regions, the fishery in the Peninsular rivers is poor both in the upper and middle reaches. The most significant difference in the rivers of the north and those of Peninsular India lies in the greater abundance of Indian major carps in the former and their poor availability in the latter which naturally has a bearing on the production of quality fish seed and its potential in the two regions.

i) The Ganga River System

River Ganga flows through the states of Haryana, Delhi, Uttar Pradesh, Madhya Pradesh, Bihar and West Bengal. The length of the Ganga river system is 8,047 km. It is the largest river and contains the richest freshwater fish fauna in India. The fish **eggs** are collected from the breeding grounds and downstream. Eggs are collected from 1-2 feet deep water by disturbing the bottom and scooping them with a gamcha. The collection of **spawn** on a commercial scale is prevalent in Bihar, West Bengal and Uttar Pradesh with Bihar alone contributing 52% of country's total production. The major carp spawn is available from May to September. The monsoon rains and melting snow are responsible for floods and bring the carp spawn. The first appearance of spawn in India occurs in the Kosi followed by the main Ganga, Gomati and its other western tributaries. Billions of carp **fry** and **fingerlings** are caught in north Bihar from July to October. The Ganga river system contributed about 89.5% of the total fish seed produced in the country.

ii) The Brahmaputra River System

It is found in the states of Assam, Nagaland and Tripura. It comprises the fast flowing rivers and is rather destitute of commercially important major carps. Length of this river system is 4,023 km. The north-bank tributaries of Brahmaputra are comparatively large with steep shallow-braided channels of coarse sandy beds and carry heavy silt, while those of the south-bank are comparatively deep. The major carp spawn is available in the lower Brahmaputra and can be profitably exploited on a commercial basis. The seed collection is made in this fast-flowing river with steep banks by fixing two long bamboo poles near the banks with a boat tied on to them across the current. The percentage of major carp spawn availability is poor. The river, being torrential and flashy due to steep gradients of its tributaries, changes its current pattern very rapidly. Hence the carp seed is less and difficult to collect.

iii). The Indus River System

The Beas and the Sutlej and their tributaries flows through the states of Himachal Pradesh, Punjab and Haryana. Length of Indus river system is 6,471 km. In Himachal Pradesh, there is no commercial fishery for major carps, with the upper reaches having cold water forms. Punjab is a good source for carp fishery. Spawn collection centers are located only on the Sutlej and its tributaries. Fry and fingerling collection, which has been the only source of fish seed till now.

iv). The East Coast River System

It comprises the Mahanadi, Godavari, Krishna and Cauvery river systems. The rivers flow towards the east into the Bay of Bengal. The length of East coast river system is 6,437 km. Mahanadi is the largest river of Orissa and the state's only major source of fish seed. The river mainly harbours the hill stream fishes from its origin upto Sambalpur. Large number of Spawn collection centers are identified between Sambalpur and Cuttack. Godavari and Krishna river system is the largest of the East coast river system, found in Maharashtra and Andhra Pradesh. No spawn collection centers exist in Godavari river in Maharashtra. The delta regions of these rivers are very rich in carp fishery, but the percentage of major carp spawn is only 20.3% in the Godavari at Rajahmundry. Fry and fingerlings of major carps, along with those of medium sized carps (*L. calbasu* and *L. fimbriatus*) are collected during the post-monsoon months from the paddy fields, in deltaic Godavari, Kolleru lake and the inundated low banks at Eturunagaram. The upper regions of the Cauvery, being fast-flowing and sufficiently cool, are unsuitable for carp fishery, the middle and lower reaches harbour a fairly good fishery of major carps and indigenous varieties *viz., Labeo kontius, Cirrhinus cirrhosa, P. dubius and P. carnaticus.*

v). The West Coast River System

The major rivers of the West coast are Narmada and Tapti, which flow in Madhya Pradesh, Maharashtra and Gujarat. Length of the river system is 3,380 km. The upper stretches of the rivers being rocky and unproductive are not suitable for seed collection. The remaining parts are good for seed collection. Narmada in Madhya Pradesh is rich in the spawn of *Labeo fimbriatus*. The Indian major carps constitute about 20-25% of the total spawn collections from the Narmada in Madhya Pradesh. The percentage of major carps in general, and *C. catla* in particular, is sufficiently high at the centres in the lower stretch of the Narmada in the Gujarat state. Narmada is the only river in India which is presently exploited for its mahseer seed (fry) regularly during October – January every year. In river Tapti, spawn collections comprised of *C. catla* and *L. rohita* and a very high percentage of minor carps which does warrant their commercial exploitation.

1.4.4. SITE SELECTION FOR SEED COLLECTION

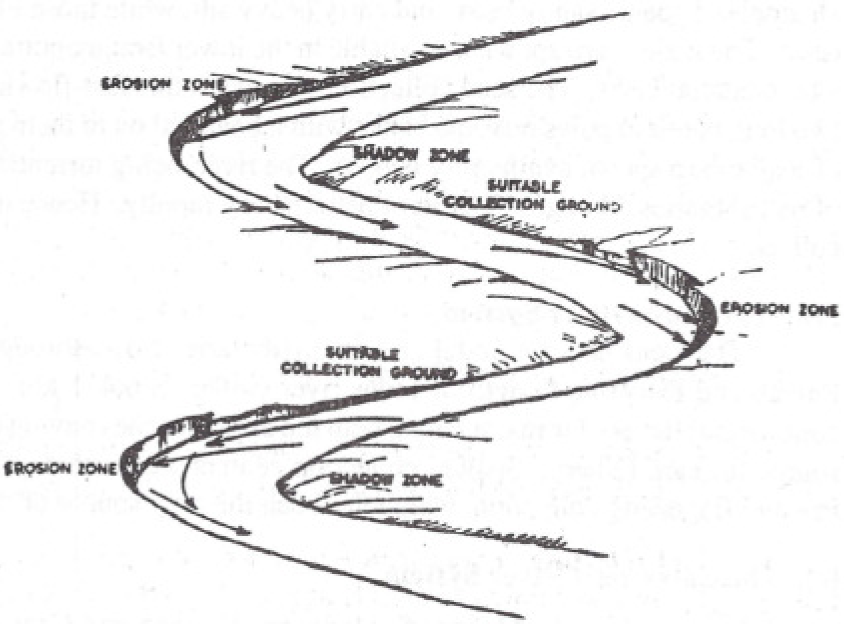


Fig. 1-23. River meanderings showing 'erosion zone', 'shadow zone' and suitable sites for spawn collection.

Fish seed collection is made after selecting suitable sites. Locations around tributaries, rivulets, and the adjoining flood inundated low-lying areas between the main river and the breeding grounds are selected as suitable sites for spawn collection. River meanderings in plains results in a serpentine course where the bends and curves of various shapes in the river course often show a precipitous fast eroding bank on one side, called '*erosion zone*' and a flat, gently sloping bank exactly opposite, called '*shadow zone*' (Fig. 1-23). Both these banks are unsuitable for spawn collection. Suitable collection sites are found on the side of the sloping bank where the water current diverges pushing off the spawn to the sides due to centrifugal force. At such places spawn collection nets are operated.

1.4.5. GEARS USED FOR SEED COLLECTION

The spawn collection net, called *shooting net*, is a funnel shaped net of finely woven netting (Fig. 1-24). It is operated in shallow margins of the flooded river. The mouth of the net faces the current and the cod end drifts along the water current. At the tail end of the net is a ring made of cane. To this ring a detachable bag known as *gamcha* is connected. The gamcha is sometimes a rectangular open piece of cloth but more often, has the shape of a monk's hood. The spawn carried by the water current are collected in the gamcha from where they are periodically removed and stored in hapas or in specially prepared mud pits. Large quantities of debris accumulate in the gamcha and injure the spawn and fry. This can be avoided or reduced if the tapering gamcha is changed into an open rectangular tank like

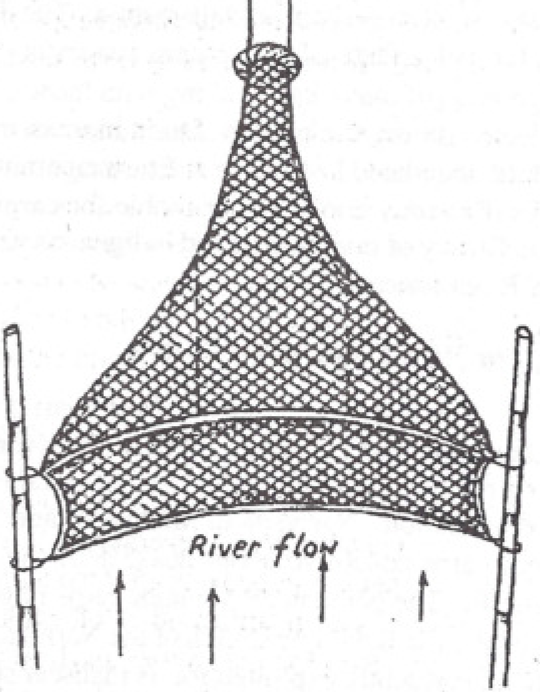


Fig. 1-24. Spawn collection net-shooting net.

receptacle (75x30x35 cm) and by introducing a screen net with a mesh size of 1.25 cm at the mouth of the net.

Benchi jal is used to collect the seed in north-eastern Bengal. However, at present appreciable variations are encountered in the dimensions of this type of net. One such net is called *Murshidabad net,* which is used in lower Ganga and Padma. A different type of net is employed in southwestern parts of Bengal called *Midnopore* net. This type of shooting net is found to be very useful and the standard one for the collection of fish seed from rivers. The net consists of a meshed netting (mesh size 3 mm) of conical structure measuring 320 cm x 310 cm x 60 cm (at mouth). The tapering net ends in a narrow opening supported on a ring of 25 cm in diameter.

1.4.6. METHODS OF SEED COLLECTION

Fish seed are collected from the major riverine systems of our country at various centers by government agencies as well as private traders and pisciculturists.

i) Egg Collection: Large scale egg collection is possible only where locations of the breeding grounds are known and easily accessible. If the exact location of the breeding ground is not known or if it is inaccessible, the drifting eggs are collected in the downstream immediately below the breeding spots. Eggs are collected from one to two feet deep water by disturbing the bottom and scooping them with a gamcha. Drifting eggs are collected by fixing a shooting net in the site. A distinct advantage in egg collection at the breeding ground is that one can be sure of its quality. Egg collection is prominent in the Ganga river system. In the fast flowing Brahmaputra river system, the percentage of major carp eggs in the collections being poor and worked out to be uneconomical. In the Indus river system, fry and fingerling collection has been the only source of fish seed till now. In East coast and West coast river systems details on egg collection are not known.

ii) Spawn Collection: During spawn collection, the *shooting net* is fixed in such a way that its mouth open wide and facing the water current, by means of bamboo poles (Fig. 1-24). The bamboo poles are fixed firmly at the selected site and the net is fixed to them. Two bamboo poles are fixed near the mouth and the other two poles are fixed at tail ring. The anterior end of the *Gamcha* is then tied round the ring, while its posterior end is fixed in place securely with the help of another pair of bamboo poles. Inorder to prolong the life of the net and the gamcha, they should invariably be pulled out of the water after 2 hours operation and dried for atleast 24 hours.

In order to select the spot of maximum availability of spawn within a specified stretch of the river concerned, a number of trial nettings are simultaneously operated at a number of suitable spots. After selecting the spots, the operation is started with full battery of nets. In one operation, two persons manage a battery of several nets from one boat. Once it is done, the collection from the tail piece of each net is scooped one after the other in quick succession every 15 minutes, depending upon the intensity of spawn collection. Collection from gamcha needs skill and training. If they are not delicately handled, physical injuries and heavy mortality would occur. Thus the contents of the gamcha are scooped carefully and transferred immediately into a container half-filled with river water. The collection is then passed through a mosquito netting sieve so that the unwanted organisms and non-floating debris can be removed. The spawn are measured by using 5 to 200 ml measuring cups and kept in hapas for conditioning. While storing in hapas, mud pits or in special earthen pots called hundies, over crowding of spawn and fry should be avoided. Then they are transported to fish farms and stocked in nurseries.

iii). Fry and Fingerling Collection: The collection is made usually by cast nets and drag nets and then stocked in ponds. In the Ganga river system, though billions of carp fry and fingerlings are caught in north Bihar from July to October, these are generally not used for fish culture operations but consumed as food and thus lost to the culture fisheries.

1.4.7. SUMMARY

1. Procurement of fish seed is an important aspect in fish culture practices. Fish seed is the term used to refer to the early stages of fish such as eggs, spawn, fry and fingerlings. Collection of fish seed from natural waters i.e. from rivers is still popular though the controlled/induced breeding techniques of major carps for producing pure and abundant seed were well established.

2. India has five major river systems constituted by different rivers of the country. They are: the Ganga river system, the Brahmaputra river system, the Indus river system, the East coast river system and the West coast river system.

3. Of all the river systems, the Ganga river system is the largest and contains the richest freshwater fish fauna in India. It is also the rich source of carp seed among the other river systems.

4. The Brahmaputra river, being a fast-flowing and flashy due to steep gradients, is relatively poor in carp seed.

5. The Indus river system is constituted by the Beas and the Sutlej rivers. Spawn collection centers are located only on the river Sutlej and its tributaries. Fry and fingerling collection which has been the only source of fish seed collection till now for the erstwhile Punjab state.

6. The East coast river system comprises the Mahanadi, Godavari, Krishna and Cauvery rivers. Mahanadi is the major and only source of fish seed for Orissa. No spawn collection centres in Godavari river in Maharashtra. The delta regions of Godavari and Krishna are very rich in carp fishery but the percentage of carp spawn is less. Fry and fingerlings of major carps and medium-sized carps are collected at various places. The upper reaches of the Cauvery, being fast-flowing and cool, are unsuitable for carp fishery, the middle and lower reaches harbour a fairly good fishery of major carps as well as indigenous varieties.

7. The west coast river system includes the Narmada and Tapti rivers. Narmada is rich in the spawn of *Labeo fimbriatus* and *Catla calta.* It is the only river in India where mahseer seed is presently exploited. In river Tapti, spawn collections include *C. catla* and *L. rohita* and very high percentage of minor carps.

8. Suitable sites for the collection of fish seed are the locations around tributaries, rivulets and

the adjoining flood inundated areas between the main river and the breeding grounds. In the plains the bends and curves of the riverine course provide what are called erosion zones and shadow zones. Both these are unsuitable for seed collection. Suitable collection sites are the sides of the sloping bank where the spawn get concentrated. At such places spawn collection nets are operated.

9. The spawn collection net called 'shooting net' is operated in suitable sites in a given stretch of river. The net is a funnel shaped net of a finely woven netting. The mouth of the net faces the water current. At the tail end a detachable bag called gamcha is connected. At present appreciable variations are encountered in the dimensions of this type of net which results in *Benchi jal, Murshidabad* and *Midnapore* type of nets.

10. Egg collection is prominent in the Ganga river system. Large scale collections are made in the breeding grounds. Eggs are collected from 1 to 2 feet deep water by disturbing the bottom and scooping them with a gamcha. The drifting eggs are collected in the downstream immediately below the breeding spots by using a shooting net.

11. Spawn collections are made by fixing the shooting nets in the collection sites with the help of bamboo poles. The mouth of the net kept open wide and facing the water current. A battery of several nets is used in one operation, managed by two persons from one boat. The spawn carried by the water current are collected in the gamcha from where they are periodically removed and stored in hapas or mud pits or hundies. Then they are transported to fish farms for stocking in nurseries.

12. Fry and fingerling collections are made usually by cast nets and drag nets. In Ganga river system most of the collections are consumed as food rather than used for stocking in ponds.

1.4.8. GLOSSARY

Breeding ground: Particular area of the body of water where breeding of a fish species takes place. Also termed as spawning ground.

Cast net: Circular net looks like a large umbrella, usually operated by a single person by throwing the net that ultimately covers the fish.

Drag net: An elongated net in which fishes are captured by horizontal dragging (pulling) of gear. Also called pull net.

Egg: The female gamete, especially when it is fertilized or released outside the body.

Fingerling: A fish larger than a fry but not of marketable size. Though not rigidly defined, fingerling fishes are generally between 4 and 10 cm long.

Fry: A stage of fish next to spawn stage when yolk sac has already been absorbed and active feeding commenced. It has the external characteristics of the adult but are smaller than fingerlings.

Gear: Tools or appliances such as net, trap, rod and line employed to catch fish.

Spawn: Newly born fish larvae.

Spawning season: Part of the year when a fish species is sexually active. Also called breeding season.

1.4.9. MODEL QUESTIONS

1. Give an account of the seed resources in major river systems of India
2. Write notes on
    a) Selection of site for seed collection
    b) Shooting net
    c) Method of spawn collection
    d) Seed availability in the East coast river system

1.4.10. REFERENCE BOOKS

Jhingran, V.G., 1991. *Fish and Fisheries of India.* Hindustan Publishing corporation (India) Delhi.

Dr. P. PADMAVATHI

UNIT – III

LESSON - 3.4

CULTURE OF TIGER SHRIMP *Penaeus monodon*

3.4.1. INTRODUCTION
3.4.2. SELECTION OF CULTURE PRACTICE
3.4.3. SITE SELECTION
3.4.4. POND PREPARATION
3.4.5. SELECTION OF SEED
3.4.6. POND MANAGEMENT
3.4.7. FEED MANAGEMENT
3.4.8. IMPORTANCE OF KEEPING DATA
3.4.9. DISEASES
3.4.10. SUMMARY
3.4.11. MODEL QUESTIONS
3.4.12. REFERENCES

3.4.1. INTRODUCTION

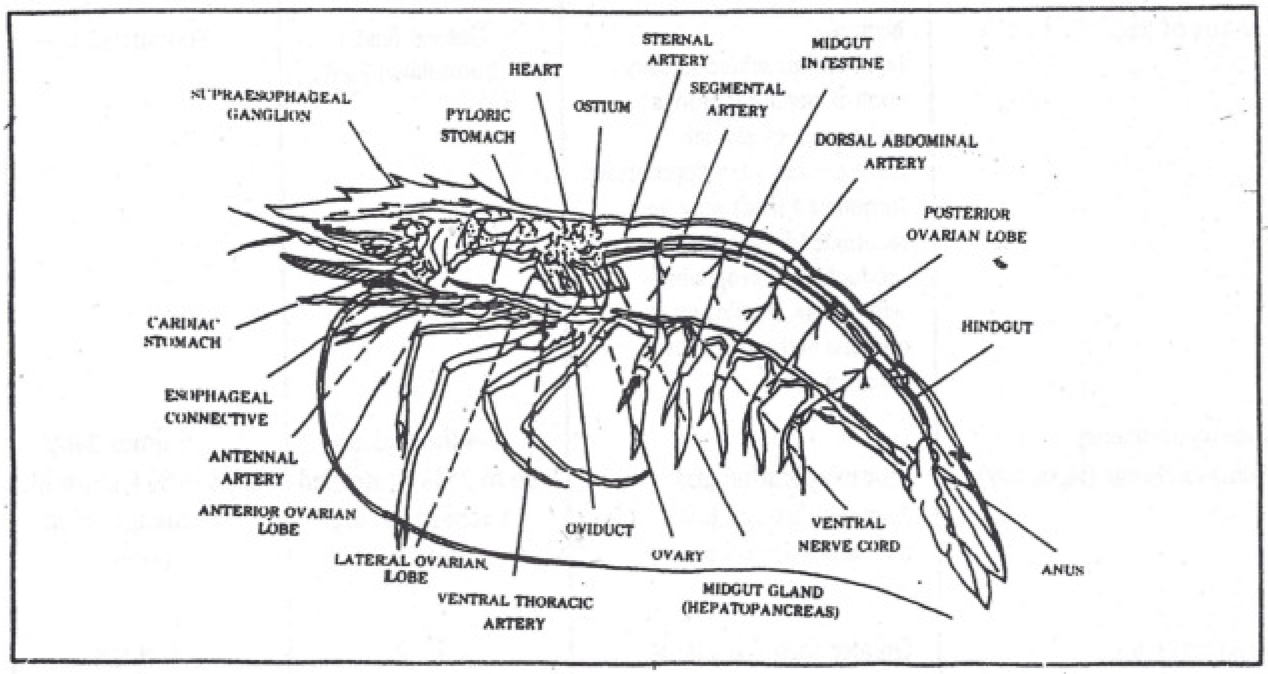
In recent years, a great deal of interest has been aroused among private entrepreneurs mostly in prawn culture especially centered on the culture of tiger prawn *Penaeus monodon,* which fetches the highest monetary value. The shrimp aquaculture technology, after commercial success in Taiwan, spread to the Asian countries including India. Crustacean fisheries of the Indian seas consist of

a. Penaeid prawn	Ex.	*Penaeus indicus, P.monodon, P.semisulcatus, P. merguensis, Metapenaeus monoceros, M.dobsoni Parapenaeopsis stylifera, P.hardwickii*
b. Non–penaeid prawns	Ex.	*Palaemon tenuips, P.styliferus, Acetus sps*
c. Lobsters & Crabs	Ex.	*Panulirus polydhagus, P.ornatus, P.homarus Scylla serrata, Portunus pelagicus*

Classification

Phylum	:	Arthopoda
Class	:	Crustacea
Order	:	Decapoda
Sub-Order	:	Macrura

Tribe	:	Natantia
Family	:	Penaeidae
Genus	:	*Penaeus*
Species	:	*monodon*



3.4.2. SELECTION OF CULTURE PRACTICE

DIFFERENT TYPES OF CULTURE PRATICES AT DIFFERENT LEVELS OF STOCKING

The motivation for shrimp culture is driven by economic factors, but it is made possible by technological break through in culture techniques. Most cultured shrimp in India are still produced in relatively primitive traditional grow-out systems. Large ponds with very little materials, energy management or cost inputs characterize these systems, known as extensive systems. Extensive grow–out is also characterized by low yields of shrimp per unit area. In places where land and labour are cheap and seed are abundant and inexpensive, this type of shrimp culture is quite profitable. Neither use of formulated feeds nor high level of pond and animal health management is necessary. Semi - intensive farming, on the other hand, requires high feed and energy inputs continuous management attention and gives high yields. Table.1 summarizes the characteristics of marine shrimp culture at three different levels of stocking density.

Table 1. Characterization of Marine Shrimp Culture at three levels of stocking density.

CHARACTERISTIC	LEVEL OF INTENSITY EXTENSIVE	 MODIFIED EXTENSIVE	 SEMIEXTENSIVE
Production level (Kg/crop/ha) Stocking density (no/sq.m) Survival percentage	300 – 800 1 – 2.5 50 – 90	1500 – 3000 5 – 10 70 - 80	4000 – 7500 15 – 30 70 - 80
Nature of feed	Natural In situations where salinity control water conditions and degree of animal management are inappropriate formulated feeds may be recommend- ded to help production of crop which will enable the farmer to obtain a better price for his crop	Natural feed + Formulated feed	Formulated feed
Feeding frequency Water exchange (%per day)	- For evaporation and seepage through tidal exchange or pumps	1-4 times daily up to 25% controlled exchange using pumps	3-6 times daily up to 40% Controlled exchange using pumps
Pond size (Ha)	Greater than 5 hectares	1 - 2	1 or less
Water depth (m) Supplemental aeration	0.5 – 1.2 Not required	0.8 – 1.5 For emergencies Supplemental	0.8 – 1.5 Continual mechanical & flushing
Requirement of Engineering of farm	Not required	Moderate	Must be engineered for sustainable production
Level of pond management required	Low	Moderate Systematic	Very high Delicate
Need of dependable electricity supply and generator backup	Not required	Partial back-up necessary	Fullback-up
First level of investment Availability of sites Harvest Size (gms) FCR	Low Wide spread 20.60 –	Moderate Wide spread 20.50 1:1 to 1:1.5	Very high Selective 20.40 1:1.5 to 1:1.7

In order to help farmers select the right culture system some interrelated aspects of pond grow-out system are discussed.

Nature of Water Source

A question often asked relates to selection of a water source for prawn farming. The characteristics and culture considerations of fresh water, seawater and brackish water from various sources are most important. Except from the underground, water sources that come from the coast or estuaries are subject to variation of water quality such as salinity fluctuations caused by rainfall, tide or current, pollution, or contamination with diseases. Underground water is sometimes high in dissolved iron, manganese and sulfide, which are in a reduced state. Therefore, when underground water is used aeration is needed to oxygenate water and precipitate iron. As water from underground wells contains no plankton it is difficult to cultivate and maintain a balanced and stable aquatic ecosystem, often indicated by frequent and drastic changes in water color. Thus use of underground water as a source of water for prawn farming is not generally recommended.

Stocking density:

In the extensive system stocking of seed is done by allowing entry of natural seed with the tide or stocking at a low rate with seed collected from nature or from hatcheries. The stocking density is generally 1 to 2.5 / sq.m.

In the modified extensive system a stocking density of 5 – 10 sq.m is maintained.

In the semi-intensive system the stocking density goes up to 15-30/sq.m.

Generally high stocking densities result in lower survival rates and lower growth rates, but Feed Conversion Ratios are good and a higher crop is harvested for a given cost of production, even though individual animals may be smaller at harvest time.

Pond size:

The size of the grow-out ponds in shrimp culture plays an important role in management of these ponds. In table 2 below, a comparison of larger vs. smaller ponds has been made with respect to certain criteria.

Table 2. Comparison of small vs large ponds.

CRITERIA	SMALL SIZE PONDS	LARGE SIZE PONDS
Construction cost (for same area)	High	Low
Control pf pond parameters pH, salinity, temperature etc.	Greater variation due to lower water mass	Lesser variation to larger water mass
Influence on shrimp on account of variation of pond parameters	Shrimp may be subject to greater stress	Shrimp are subjected to lesser stress
Management required	Higher	Lower
Extent of effort in pond preparation (tilling, grading, sterilizing & liming)	Low	High
Extent of effort in feeding, harvesting, disease control, monitoring biomass and growth rate	Low	High

It needs to be borne in mind that there is little data to suggest differences in growth rates, survival rates or feed conversion ratios as a function of pond size alone. There is no ideal pond size. Earthen ponds typically vary in size from 0.5 Ha to 4.5 Ha in India. One must consider trade-off between construction costs, which favour large ponds versus land cost and availability. Greater control over pond management, which favours small ponds. As a general rule, large ponds are less suitable for semi-intensive shrimp culture due to inherent limitations on water exchange, feed management and control of water quality. For extensive culture ponds of one hectare size, length: breadth ratio of 1.5 : 1 are considered appropriate. For semi-intensive culture if the farm size is less than 5 hectares, 1 ha ponds are considered appropriate. For larger farms, smaller ponds are most appropriate from the point of management.

Decision on pond size cannot be made on the basis of hard and fast rules. The decision is subjective and is a trade off between lower construction cost of larger ponds and expected easier management of small ponds.

Pond soils:

Soils influence the culture system directly. Depending upon their constituents (ratios of clay / silt / sand) they assist in the growth of benthic algae. However, soil alone, is not the only factor, for growth of benthic algae is related to the amount of organic and inorganic fertilizers, pH value and water depth. Benthic algae are the basic nutrition source in the culture system, but in the intensive systems, it is less important and is only used as an indication of real quality. Generally compact soils with high clay content are more appropriate. Soils very high in clay content are difficult to work with machinery during construction, whereas porous and loose soils may suffer from high water seepage and difficulty during harvest because prawns may burrow.

Water exchange:

Adequate water exchange is one of the most important factors and it reduces greatly the requirement of an active water quality control. It does, however, limit the flexibility of fertilizing ponds. However, depending upon the exchange rate, biomass and feeding rate it can be beneficial in removing uneaten food.

Water depth:

Even through prawns are bottom dwelling organisms, the depth and therefore, volume of water in a pond, has certain physical and biological consequences. The volume of water behaves like a physical buffer, which prevents weather fluctuations from influencing the environment in which the prawn lives. On the biological side the volume represents the capacity of the system to sustain a microorganism population which includes bacteria, phytoplankton, zooplankton and benthos.

Changing water has a beneficial impact on water quality, removing the accumulation of waste products and introducing new food organisms in to the pond. It needs to be noted that in a pond where water is not changed for a long period of time either all desirable food organisms will be eaten or a species not suitable as food organisms for prawns may become dominant. Water exchange in extensive systems is a means of suppressing growth of undesirable species. As the stocking density is increased, water exchange acquires the more important function in monitoring water quality. It helps to drain out wastes and uneaten food and ensure adequate oxygen level in the pond water.

The ideal water depth is between 0.8 m and 1.5 m depending upon the stage of culture. It is recommended that a minimum depth of 1m be maintained at operational level. Deeper ponds are susceptible to DO stratification unless adequate aeration is employed. Since ambient temperature conditions in India vary, deeper pond depth is recommended in hotter climate (Andhra Pradesh & Tamilnadu).

Aeration:

Aeration is correlated with water exchange rate i.e. higher the water exchange lower is the need for aeration and vice – versa. In semi-intensive and intensive culture systems aeration is needed. Aeration also helps in eliminating temperature and salinity stratification, which cause lower oxygen availability near pond bottom.

Feeding:

Shrimp grow-out feeds can be classified into 3 categories:

1. Natural feeds including phytoplankton, zooplankton, benthic layer etc.,
2. Prepared natural feeds, including fresh fish, clams, mussels etc.
3. Commercial formula feeds, which are usually available in crumble or pellet form, are variable in nutritional effect depending upon use in modified extensive or semi-intensive culture systems.

Feeding rate of the natural feeds is usually 2 to 4 times the quantity used of formula feeds, and this quantity is only the weighed meat portion. Undigested parts such as skeleton and shells are excluded. For modified extensive systems feed quantity daily between 1% and 3% of total body weight of the prawns per day is recommended. Frequency is normally 1 to 4 times a day since formula feed is supplementing the natural food. In semi – intensive systems feeding rate is normally 3 % or more of total shrimp bio-mass in the pond and the feeding frequency is 3 to 6 times per day depending on the culture period.

3.4.3. SITE SELECTION

A suitable site is one of the most important criteria for successful prawn farming. It is the site which can support optimum conditions for the growth of prawns at the targeted production level, given an effective pond design and support facilities. The following are the important features that a site selected for prawn farming should possess.

PRAWN FARMING SITE CONDITIONS:

1. Average air temperature of 26^0 C.
2. Average pond temperature of 30^0 C.
3. Salinity of 10 – 25 ppt year round
4. Estuarine water of high natural productivity
5. Pollutants should not contaminate water. Locate site far from industrial activity.
6. Low flood risk
7. Good level of sunshine round the year. Low cloud level.
8. Low evaporation rate – function of ambient temperatures and humidity level round the year.
9. Land of suitable elevation to enable drainage at highest high tide level.
10. Clay or clay loam soil.
11. Depth of the water table should be located. Particle analysis, soil texture, permeability, shear and compaction tests may also need to be done to ensure appropriate dyke design.
12. Soil pH in excess of 6.0
13. Good electricity connections and supply.
14. Good availability of labour.
15. Reasonable road and transportation to the site.
16. Reasonable communication.
17. Availability of formulated feed and natural feed.
18. Availability of equipment supply and maintenance.
19. Proximate processing facilities.
20. Availability of fry/seed round the year.

21. Assessment of existing farms in the vicinity and their water sources and water drainage points and environmental impact assessment.

FARM DESIGN AND POND LAYOUT

1. **Degree of water exchange flexibility required at any given time.**
2. Contingencies that may be faced during operation and management.
3. Source and quality of water under all tidal and weather situations.
4. Drainage facility for the ponds under all weather conditions.
5. Matching predominant wind direction parallel to longer side of the pond to take benefit of natural aeration.
6. Adequate shape of farm dyke considering soil parameters.

3.4.4. POND PREPARATION:

Cleaning of ponds

In newly constructed ponds this step may not be significant. However, in case of old ponds, which are in use, the water is first drained and the accumulated detritus and the deteriorated bottom soils are removed. In ponds which are not drainable deteriorated soil and detritus is pumped out.

Sun drying

The pond bottom is exposed to sunlight for drying for a period ranging from 10 – 30 days according to the nature of the site till cracks are developed in the soil. This will help in mineralisation of organic matter in the soil thereby enhancing its fertility. In case of acid sulfate soils caution is needed. In acid sulfate soils drying leads to the oxidation of pyrites and when such ponds are filled with water acids are formed causing reduction in pH. Such ponds should be flushed thoroughly to wash away the acids.

Ploughing and leveling pond bottom

Ploughing the pond bottom to a depth of 15 - 20 cm helps release of poisonous gases such as Hydrogen sulfide produced under anaerobic conditions in the soil and augments mineralisation. Ploughing also helps spreading the effect of liming to deeper levels of soil.

Liming

Liming of the pond is done in view of a number of advantages. This helps in killing unwanted organisms in the soil and raises the soil pH, which is one of the most important parameter in shrimp culture. The quantities of lime to be applied to soils of different pH are given in the following table.

Quantity of lime needed (tonnes / ha) to raise the pH to 7

Soil pH	Ag. lime ($CaCO_3$)	Hydrated lime ($Ca(OH)_2$)	Quick lime (CaO)
6.5	2.5	1.9	1.4
6.0	5.0	3.7	2.9
5.5	7.5	5.6	4.3
5.0	10.0	7.4	5.8
4.5	12.5	9.3	7.2
4.0	15.0	11.2	8.7
Efficiency	100%	135%	173%

The lime requirement is calculated by using this formula

$$\text{Lime Needed} = \frac{\dfrac{\text{Desired pH} - \text{Actual pH}}{0.1} \times 0.5}{\text{Efficiency of lime}} \times \text{Area}$$

Zeolite is also used to achieve the soil conditioning effect. Zeolite is a complex oxide of aluminum, silicon, iron, calcium, magnesium etc. However good quality zeolite occurs in very small quantities.

Water filling

Water is allowed to enter in to the pond through suitable inlets covered with required mesh to prevent the entry of unwanted organisms in to the pond. The water is filled up to 25 cm depth and the fertilizers are applied. After the development of suitable colour formed due to the development of plankton, the water column is raised and maintained at an optimum level of 100 – 125 cm.

Chemicals and fertilizers

Normally organic and inorganic fertilizers are used. Chicken manure should only be used in ponds having poor productivity and in small quantities because of its high fertility. Cow manure has lesser fertility than chicken manure. Organic manure should only be used after extreme sun-drying to eliminate bacteria. Nitrogen based fertilizers used include Urea, ammonium sulfate, etc. Single superphosphate is the most commonly used phosphate fertilizer in the pond. The principle of fertilizer application to water cultivation is to apply a smeller quantity with greater frequency, taking care of the organic load in the pond water and pond bottom and ensure that it does not become excessive through fertilization.

3.4.5. SELECION OF SEED

The most important criteria for selection are the stage of development of the fry. Identification of anatomical parts of the fry will require a microscope but a farmer could do well with magnifying lens to the hatchery. An important question which confronts every prawn farmer is the age at which to stock prawn fry. It has been observed that the age of stocking influence degree of size variation and harvest, survival and saving in culture time. Stocking younger animals, between PL-10 to PL-20, makes it difficult to determine survival rate up to 45 to 60 days. Feeding during the initial period is based upon an assessment of survival, which may be proving incorrect.

Stocking prawn fry of age greater than PL-20 enables the farmer to get a good feel of survival, and thereby control feeding. This also ensures that the hatchery deals with the mortalities by keeping the fry up to PL-20. Late age stocking does not, however, reduce the culture period in the pond correspondingly, i.e. stocking PL-40 does not reduce pond culture period by 20 days. It has also been observed that stocking older animals results in a greater size variation during culture, which has impact on pond management. It is always easier to manage a pond with lesser size variation, i.e. animals with a narrow size range.

The criteria for the selection of fry

a. Uniformity of size. Larger animals are generally more aggressive in searching for food and have a better chance of survival over smaller ones. It is preferable to stock fry of uniform size.

b. Healthy fry are usually active and a slight disturbance causes them to jump towards solid surfaces. This activity of fry can be easily observed if water in basin containing fry is swirled, prior to packing. The healthy ones move to the sides against the current whereas the weak ones remain in the centre.

TRANSPORTATION OF PRAWN FRY

Most hatcheries are located far away from ponds and fry have to be transported to pond area. In order to ensure good survival after seeding in the pond it is necessary to communicate to the hatchery the pond parameters so that the hatchery is able to modify the water parameters at the nursery stage itself. Current industry practice is to pack 2,000 – 2,500 post-larvae in plastic bags, which are oxygenated, sealed and packed in cardboard cartons lined with thermocool. If transportation time to the ponds is more than six hours, it is recommended that the temperature is lowered to between 20-26^0 C by adding small bags with ice on top and around the bags containing the fry. Reduction in temperature should also be gradual to avoid any stress on the animals. Temperature reduction is done to reduce the metabolic rate and oxygen consumption.

ACCLIMATIZATION AND STOCKING

The best stocking time is early in the morning or after 6 pm at night. The collection and transport from the hatchery can be co-ordinated to match the stocking time. It is advisable to postpone delivery of fry from the hatchery if the algal bloom in the pond is not correct. Seeding schemes differ for small and large farms. For small farms the seeding process will be as follows:

1. Empty the fry bag in a plastic container or basin.
2. Observe the fry for level of activity and mortality.
3. Lower the basin till it floats in the water. The water of the container should not mix with the pond water.
4. Hold the basin with one hand, and add water of the pond into the container slowly. After sometime tilt the basin. The fry should slowly swim out into the pond water.
5. If fry do not swim out quickly then differences in pond water parameters and the hatchery parameters are more and it requires further acclimatization.
6. While stocking, care needs to be taken that no sediment is stirred up. The persons who are standing in the water handing the plastic tub should not move rapidly. For larger farmers stocking up to $30/M^2$ the procedure described above will require a large number of workers and also a longer time.

3.4.6. POND MANAGEMENT:

Environment and nutrition are the most important factors, which contribute to the success of prawn farming. Both these terms are made up of numerous integrated parameters, which effect and supplement each other. As stocking density is increased, pond parameters go through more drastic changes. This can be attributed to large nutrient loads as well as to sudden changes in the phytoplankton and microbial population. Understanding the inter-relationships of the changes in water quality parameters can allow one to develop strategies to monitor and implement schemes for maintaining good water quality and achieve the optimum growth.

WATER QUALITY PARAMETERS AND BIOCRITERIA

The optimal water quality parameters of shrimp culture ponds are given in the following table.

The maintenance of good water quality is essential for both survival and optimum growth of prawns. Good water quality is characterized by adequate oxygen and limited levels of metabolites. The prawn, algae and microorganisms such as bacteria produce metabolites in a pond. The major source of nutrients in intensive prawn culture is the feed. Because large quantities of feed are loaded in ponds, excess feed, fecal matter and other metabolites become available in large quantities for the growth of algae and microorganisms. At one point, the increase in population of algae and microorganisms is exponential. This usually occurs during the second half of the culture period because of available nutrients. About 30% of the total feed requirement is loaded into the pond during the third quarter of the culture period and about 50% is loaded during the last quarter. The algae and microbial population increase until a factor required for growth becomes limiting, after which a sudden decrease in the population can occur. This is referred to as a "collapse" or a "die-off". The sudden increase or decrease in algal and microbial population can cause drastic changes in water quality parameters, which may affect growth. Ideally, one would want to understand what is happening in a pond so that a scheme to detect and correct any factor that would slow down the growth of prawns can be implemented.

Temperature

Prawns are cold-blooded animals. They can modify their body temperature to the environment in normal condition, unlike the warm-blooded animals which can react to maintain the optimum body temperature. The optimum range of temperature for the Black Tiger is between 28 – 30° C. Temperature increases beyond 30° C increase the activity level and the metabolism. This also increases the growth rate. If the temperature still increase then the shrimp reaches a threshold of physical and nutritional tolerance, which is 33° C in poor quality water or 35° C in good quality water, and remains stationary at the pond bottom.

Salinity

The optimum range of salinity for semi intensive culture is between 10 and 25 ppt, although the prawn will survive and grow at salinity between 5 and 38 ppt.

Dissolved oxygen

Oxygen is one environmental parameter that exerts a tremendous effect on growth and production through its direct effect on feed consumption and metabolism and its indirect effect on environmental conditions. Oxygen affects the solubility and availability of many nutrients. Low levels of dissolved oxygen can cause changes in Oxidation State of substances. Lack of dissolved oxygen can be directly harmful to prawns or cause a substantial increase in the level of toxic metabolites. It is therefore important to continuously maintain dissolved oxygen at optimum levels of above 3.5 ppm.

A strategy to maintain optimum levels of DO would be to take advantage of major factors that increase DO and put into check the factors that decrease DO. Photosynthesis plays a major role in oxygen production; respiration of all living organisms in the pond is the major factor involved in oxygen consumption. Oxygen concentration in pond water exhibits a diurnal pattern, with the maximum occurring during the peak of photosynthesis in the afternoon, and the minimum occurring at dawn due to night time respiration. Diffusion at night can be tremendously facilitated with the use of aerators which exposes more water surface to equilibrate with atmospheric oxygen. Through reverse diffusion, an aerator operated during the day will tend to remove supersaturated DO.

This phenomenon is commonly observed when a cyclone occurs. Photosynthetic oxygen production is also significantly limited when a plankton die-off occurs. Under these conditions, flushing out decaying plankton, providing for additional aerators and aerating for additional hours may be necessary to maintain DO at optimum levels.

pH

It is an important parameter to consider because it affects the metabolism and other physiological processes of prawn. A certain range of pH (pH 6.8-8.7) should be maintained for acceptable growth and production. But in semi intensive culture, the optimum range is better maintained between pH 7.6-8.5.

pH changes in pond water are mainly influenced by carbon dioxide and ions in equilibrium with it.

Like DO, a diurnal fluctuation pattern that is associated with the intensity of photosynthesis occurs for pH. This is because carbon dioxide is required for photosynthesis and accumulates through nigh time respiration. It peaks before dawn and is at its minimum when photosynthesis is intense.

Water Turbidity

Water turbidity refers to the quantity of suspended material which interferes with light penetration in the water column. In prawn ponds, water turbidity can result from planktonic organisms or from suspended clay particles. Turbidity limits light penetration, thereby limiting photosynthesis in the bottom layer. High turbidity can cause temperature and DO stratification in prawn ponds.

Nitrogen Metabolites

Large quantities of organic matter originating from the heavy feed load, accumulate in semi intensive prawn ponds and undergo oxidation-reduction reactions leading to decomposition, mainly through the action of bacteria. Different forms of inorganic nitrogen are produced during decomposition.

Ammonia is continuously released during the culture period. Toxic levels of ammonia are reached when the mechanisms for assimilation, trapping and oxidation fail. Aeration of the pond bottom enhances nitrification.

Phytoplankton Management and Water Colour

Phytoplankton play a significant role in stabilizing the whole pond ecosystem and in minimizing the fluctuations of water quality. A suitable phytoplankton population enriches the system with oxygen through photosynthesis during day light hours and lowers the levels of CO_2, NH_3, NO_2, and H_2S. A healthy phytoplankton bloom can reduce toxic substances since phytoplankton can consume NH_4 and tie-up heavy metals. It can prevent the development of filamentous algae since phytoplankton can block light from reaching the bottom. A healthy bloom also provides proper turbidity and subsequently stabilizes shrimp and reduces cannibalism. It decreases temperature loss in winter and stabilizes water temperature. It also competes for nutrients with other microbes and lowers pathogenic bacteria population while increasing the density of food organisms and subsequently reducing cost of supplemental feed. Maintaining a stable water color is the key factor in water management. The color of pond water usually indicates the predominant phytoplankton species. A change of water color or its intensity indicates changes of phytoplankton fauna and densities. Sometimes the water clears suddenly resulting in mass mortality of phytoplankton. It usually takes place when the phytoplankton population reaches the peak of its reproductive cycle, or the physicochemical environment suddenly becomes unfavourable to phytoplankton, such as a drastic salinity or temperature change or a shortage of nutrients, or through massive grazing of zooplankton. Phytoplankton can approach their peak rapidly during warm days in intensive culture ponds where nutrients are abundant. Caution should be taken when plankton is getting dense.

Mass mortality of phytoplankton during warm days poses a threat to the prawn survival. High temperature hastens the decay of the deposited dead plankton cells and concomitantly the consumption of oxygen. The resulting anaerobic sediment can release ammonia and sulphide, which stress the benthic shrimp, implying the need to build a capability to do rapid water exchange in semi-intensive prawn farms in India.

Mass mortality of phytoplankton usually proceeds in four stages. First, water colour intensity increases progressively. The color intensity is homogeneous throughout the water column. This occurs when a few phytoplankton species have become dominant in the community and have started to propagate rapidly. Second, clusters of colour appear on the water surface. This occurs when some of the phytoplankton have not yet ruptured. Third, milky clouds appear in the water column, water becomes sticky, and scum and foam form on the water surface when paddle wheels are running. This occurs when the cell walls of the phytoplankton have ruptured, the cell substance and pigment have reached out, and the phytoplankton has lost its color. Fourth, water clears up and the transparency readings dramatically increase. The dead phytoplankton are no longer suspended in the water, and either float up or sink to the bottom.

What to do when an algal Bloom collapse takes place:

A. For extensive farming 30-50% water exchange has to be done. Using pond bottom drain, followed by lime (shell lime) application, inoculation (Transferring pond water from a healthy/ good pond into adjacent pond. This will help to improve the water condition of that pond) from a neighbouring healthy pond and fertilizer application.

B. For semi-intensive farming – keep aerators on, to maintain dead algae in suspension. Later 30-50% water exchange has to be done using bottom drain followed by shell lime application, inoculation, and fertilization to correct water color.

Water color, including true color and apparent color, is a color appearing under the sunshine, and is made of microorganisms, dissolved matters and minerals, clay particles, organic particles, pigments, and suspended colloids, etc. Generally, microorganisms, comprising phytoplankton, zooplankton and bacteria, are the major among all that can form the visible color, and the main reason that causes the change of water color is the variation and fluctuation of micro-organisms, especially the phytoplankton.

Transparency

There is a high correlation between secchi disc visibility and water color density. Secchi disc visibility is the average of the depth at which a disc, a round plate with alternating black and white quadrants, disappears and reappears from view when sunlight is intense or moderate. The optimum range for secchi disc reading is between 30 and 60 cm to the juvenile stage, and between 25 and 40 cm to the sub-adult and final stage. High secchi disc reading is associated with low productivity of the pond. And low secchi disc reading is associated with high biomass that increase oxygen consumption, which may lead to oxygen depletion at dawn.

TECHNIQUES FOR MAINTAINING GOOD WATER QUALITY

As pond conditions change, appropriate management schemes can be implemented when one is aware of the requirements for good water quality and can properly diagnose the problem. Schemes that do not involve the use of chemicals such as aeration and water exchange are preferable. Liming materials, coagulants and fertilizers are regarded as safe for use. The use of therapeutants and other chemicals, should be avoided and when necessary, applied with caution. These must necessarily be used as a last resort and after taking advice of a technical expert.

Chemicals used in ponds should provide a comfortable margin of error between a safe treatment rate and the concentration toxic to prawns. Appropriate methods for application are important. The volume of water in the pond should be properly estimated and the percentage of the active ingredient of the chemical, should be determined. The required quantity can be computed using the following equation:

$$\text{Quantity of chemical} = \frac{\text{Volume of pond water x targeted concentration}}{\text{\% active ingredient}}$$

The chemical is diluted first in a bucket of water and distributed over the pond using a dipper.

Water Exchange

It has been discussed earlier that pond environment and animal nutrition are the two key-factors to succeed in prawn farming. Water when compared to the soil, is a more important factor to achieve success in prawn culture. It is not advisable to treat water before discharging into the pond when a good source of water is not available. And use of chemicals to treat the water of inappropriate quality is neither logical nor economical. Water exchange is atypical method to improve the water quality of pond environment when good quality of water is available. Recommended daily water exchange schedules are as shown in Tables 4.

Table. 4 Water exchange and management for the optimum growth of black tiger in semi intensive culture.

CULTURE PERIOD (IN DAYS)	OPTIMUM SALINITY (IN PPT)	WATER DEPTH (IN CM)	WATER EXCHANGE RATE (DAILY IN%)	TRANSPARENCY (IN CM)
0 – 15	25 - 30	80	2.5	40 – 60
16 – 30	20 - 25	90	5 – 7.5	30 – 60
31 – 45	20 - 25	100	10 – 12	30 – 50
46 – 60	15 - 22	100 – 120	12.5 – 15.0	30 – 40
61 – 90	15 - 20	120 – 150	15.0 – 20.0	25 – 40
91 – 120	18 – 22	120 – 150	20.0 – 25.0	25 – 40
121 – till harvest	25 – 30	120 – 150	20.0 – 25.0	25 – 40

3.4.7. FEED MANAGEMENT:

Feed management differs depending on the culture method adopted, in the traditional and extensive culture method, feed management is passive and reliance is almost completely upon the feed organisms provided by the natural environment of the pond or developed in the pond by some active fertilization. In the modified extensive system additional supplemental feed becomes necessary. The extent of reliance on fresh feeds as against use of formulated feed is a question of economics and availability of fresh feeds vs. formulated feeds and the perceived feed efficiency is a function of experience.

In the semi-intensive culture system, a well-defined and controlled diet scheme must be pursued using formulated feeds to replace of minimize the dependence on natural feeds.

FACTORS INFLUENCING FEED MANAGEMENT

There are at least nine major variables that are to be considered in formulation of shrimp feed.

1. Species of shrimp
2. Stage of growth
3. Water quality and temperature
4. Presentation
5. Feed stability
6. Type and quality of feed
7. Feeding rate and management
8. Effect of feeds which occur naturally in the rearing environment
9. Health of shrimp

NATURAL FEEDS

All cultured shrimp take advantage of some natural feeds. When one recognizes that dissolved organics, bacteria, plankton, and detritus as well as the benthic layer "lab-lab" are all natural feeds, it becomes clear that keeping even the most highly controlled culture entirely free from natural feeds is as difficult as it is inadvisable. The practical prawn farmer is well advised to encourage the growth of all varieties of natural feeds in the pond. This approach, of course, cannot be overdone without impairing water quality. Prawn ponds, which consistently produce higher yields, have greater availability of natural foods indicating that natural productivity contributes significantly to prawn production.

Benthic Layer "Lab-lab"

Mostly benthic blue – green algae and diatoms, and many other forms of plants, microorganisms and animals that are associated with it and contribute to its nutritional value, characterize lab-lab. For good growth of lab-lab it requires low water levels from 20 to 60 cm so that the sunlight can penetrate to the bottom. Best growth is reported to be at salinity of 25 ppt or little higher. Sometimes with the change of salinity and temperature, benthic algae turn to have more filamentous blue-green algae. Lab-lab can be used for prawn culture during the first two months of culture or up to a point when the prawns grow to a size of 10 cm.

Preparation of the pond soil is very important in growing lab-lab. To assure a uniform growth of algae, the pond bottom should be leveled so that there are no high points or depressions. The pond bottom must be firm enough to serve as a hold fast for the algae, but not hard. Soils with a high clay content support the best growth of lab-lab. The relation between soil texture and algal growth has been mentioned earlier.

Growth of benthic algae is also related to the amount of organic matter, inorganic mineral, pH value, and water depth. The importance of the benthic layer in pond ecosystem as a basic nutrition resource in the extensive culture system implies that it should be well cared for and it may even be necessary to apply organic or inorganic fertilizers to culture it. But in the semi-intensive system, it is usually developed spontaneously and plays a less important role in the nutrition of prawn. Nevertheless, it does serve as an indicator whether the bottom condition and the soil quality are in good condition.

As the culture enters the second month, and as the water colour becomes denser the lower transparency will gradually transform this benthic layer from that containing more algae composition to a state of having a higher bacterial composition, which originates from the organic debris of feeds. A newly formed benthic bacterial layer is accompanied by other fungi, protozoans, nematodes and crustaceans and plays two contrasting roles of that of a natural feed and as a deterioration resource at the pond bottom.

Phytoplankton and Zooplankton

Phytoplankton is composed of small plants which float in the water. A pond in which phytoplankton grows has a lot of zooplankton which also serve as food. Shrimp do not feed directly on the phytoplankton. They feed on the small animals and zooplankton that eat the phytoplankton or on bacteria that grow on the dead phytoplankton cells which accumulate the bottom.

The conditions suitable for growing phytoplankton are well suited for shrimp growth at all life stages. Phytoplankton production is better in ponds with a water level of 70 cm or more, but it has also been grown in shallow ponds. One must keep in mind that phytoplankton is composed of living organisms which have environmental tolerance. Most types of phytoplankton are normally found in deeper water where temperature does not rise, as it does in shallow ponds. The high temperature might restrict their growth.

There are many species of phytoplankton or algae, some of them are beneficial to prawn culture in many aspects:

1. Stabilize the water quality, through absorption of inorganic mineral and other mechanism.
2. Provide nutrition resource in direct form or indirect form and reduce the feeding quantity.
3. Increase the thermal capacity of the water. The pond temperature fluctuate less.
4. Provide Oxygen by photosyntheses during the day, although it consumes some Oxygen during nighttime.
5. Environmental indicator on the process of mineralization and eutrophication.
6. Stabilize the pond environment that can affect the prawn behavior.
7. Reduce the toxic effect of ammonia, hydrogen sulfide and other toxins.
8. Inhibit the development of benthic algae and filamentous algae.
9. Compete with bacteria and this may decrease the possibility and frequency on the occurrence of the disease.

FRESH FEEDS

Fresh feeds also serve form the nutritional resource in the pond culture. Fresh feed is beneficial in the following way:

1. To supplement natural productivity when growth of natural feed in a pond depletes.

2. Good source for animal proteins, lipids, minerals, vitamins and some trace elements is the fresh meat.

3. To match the abnormal requirements against physiological and environmental stress in case of insufficiency of the standard formula feed.

4. For the same quantity, fresh feeds serve the nutritional needs better than formula feeds. However, they have a far more contaminating effect that causes deterioration of pond bottom and poor water quality.

There are many kinds of fresh feeds used for prawn culture such as trash fish, snails, mussels, clam, small shrimp, crab and squid, etc. Until and unless these raw feeds are available fresh, their use should be avoided since they may have a marked negative impact. In the semi-intensive culture system, fresh feeds play the role of supplement to the formula feeds. Therefore they are not used occasionally but also as necessary and when available. Before application it will be necessary to determine the feeding quantity. It is calculated on a base of digestible portion, excluding the bone and shell. Water content of digestible part is between 70% and 80%, where the moisture content of the formula feed is between 9% and 15%. If we consider the dry weight of fresh feeds to be used for feeding, fresh feeds should be weighted three to five times of the formula feed requirement. However, if we consider the impact of contamination of feed detritus to the water quality control, it should be weighted only twice the amount of the digestible portion. The purpose of this calculation is to ensure consumption of fresh feed in a short time, shorter than the normal feeding time.

Selection of prawn feed

Selection of good feed is vital for long-term sustainable output from a prawn farm. Quality of feed has a direct impact upon prawn growth and also influences the next cycle of crop depending on the kind and extent of metabolites left in the pond after harvest.

It is easy to say that a good feed is that which at a lowest cost supplies the required nutrient needs, is attractive to the prawn and is stable enough so that it does not pollute the water before it is eaten by the shrimp. But it is difficult to develop criteria/methods to select a feed and predict behaviour in the pond. Criteria for selecting a good feed are given below.

1. **Appearance:** The feed should be of uniform colour and shape. White spots indicate improper mixing of ingredients. Dark colour indicates poor quality ingredients or overcooking. The feed should contain no impurities and should be free of fungi, insects, etc. There should be no caking of feed.

2. **Size specification:** Depending on the stage in the culture we have to select the feed size.

3. **Feel:** The feed should not contain any powder material. If a hand is pushed into the feed and withdrawn, no powder should be sticking to the fingers. Powder reflects poor quality of processing. Powder in feed will also get blown away during application of feed resulting in wastage. Powder that falls in the pond will also pollute the water.

4. **Smell:** Smell of fresh fish indicates good feed.

5. **Water stability:** Water stability can be tested by putting the feed in a glass of water. Feed should maintain shape for at least 2 hours. Also it should be noticed that some colour should diffuse into the water within 30 minutes, indicating that the attractant in the feed has dispersed. Water stability is important since prawns are slow eaters and nutrients should not leach out and pollute the water.

6. **Taste:** Good feed should be slightly salty and give a sweet after taste indicating use of good fishmeal. Bitter aftertaste indicates rancidity of oil used. A clean bite also indicates that the moisture content is low.

THE FEED EFFICIENCY OF PRAWNS

Measured by feed conversion ratio (FCR), it is a function of the quality of feed, kind of feeding management adopted and the pond environment. It needs to be noted that FCR in two different ponds of the same farm can be different. FCR will normally be higher in ponds with poor water quality as feed efficiency decreases when shrimp are stressed. This implies that quality of prawn feed cannot be assessed in ponds that do not have optimal environmental conditions for growth or those, which are poorly managed. (The role played by the natural food in the pond decreases as the stocking density increases). The field test of a feed is best done in a properly managed pond, i.e., proper feeding control/monitoring and water management, with a stocking density of 25-30/Sq.m and then if the pond gives good results as assessed by good growth and good FCR, a conclusion can be drawn that the feed is good.

FEEDING MANAGEMENT SCHEME

There is a lot of differing opinion about the optimum feeding time and frequency, feeding rate and methods of determining feeding rate for prawns. This is reflected in the different feeding schedules suggested by feed manufacturers to prawn farmers. The feeding schedule of prawn was presented in Table. 6.

Table - 6. Feed Schedule for the Tiger Prawn, *Penaeus monodon*

NUMBERS OF DAYS G / piece	AVERAGE BODY WEIGHT. RATE PER DAY	AVERAGE GROWTH	FEEDING RATE
1-5	PL-15. -0.02	60%	20%
6-10	0.02-0.10	45%	20%
11-15	0.10-0.35	30%	20%
16-20	0.35-0.87	20%	16%
21-25	0.87-1.40	10%	12%
26-30	1.40-2.00	8.5%	10%
31-35	2.00-2.80	7.0%	9%
36-40	2.80-3.70	5.7%	8%
41-45	3.70-4.65	4.7%	7%
46-50	4.65-5.65	4.0%	6%
51-55	5.65-6.65	3.3%	5%
56-60	6.65-7.71	3.0%	4.5%
61-65	7.71-8.80	2.7%	4.0%
66-70	8.80-9.98	2.53%	3.8%
71-75	9.98-11.24	2.40%	3.6%
76-80	11.24-12.60	2.33%	3.5%
81-85	12.60-14.10	2.27%	3.4%
86-90	14.10-15.70	2.20%	3.3%
91-95	15.70-17.5	2.13%	3.2%
96-100	17.50-19.40	2.07%	3.1%
101-105	19.40-21.50	2.07%	3.1%
106-110	21.50-23.80	2.00%	3.0%
111-115	23.80-26.30	2.00%	3.0%
116-120	26.30-29.10	2.00%	3.0%
121-126	29.10-33.30	1.95%	2.9%

Feeding Tray

Feeding tray method is the most practical way to monitor the feeding. Together with the cast net method, it is also the only way to predict the survival rate and the daily feeding quantity according to the average body weight or prawn biomass in pond.

Observation on feeding

While checking the feeding tray, one should also observe the following:

1. Feed quality, by observation and feeling any remaining uneaten feed
2. Feed consumption amount to observe whether the feed is partly consumed.
3. Feeding behaviour of prawns.
4. Any fecal matter of prawns.
5. Activity and health of prawns.
6. Growth of prawn.
7. Presence of any predators or competitors.

It is also necessary to identify what needs to be observed to monitor the health and condition of prawns in the ponds. During daily examination of prawns on feed trays it is necessary to look for the following:

1. Lack of feed in the intestine.

Prawns that are ill cease to eat, and those, which are beginning to suffer eat less than normal. This observation must be in conjunction with feed tray results. If there is no feed on the tray, the prawns may have been underfed.

2. Lack of tail extension.

Prawns that are weak do no flick strongly when picked up. Also if held at the base of the tail, healthy prawns extend themselves fully.

3. Lack of luster or shine on the shell

An early sign of diseases beginning to appear is that the prawns will have dull hard shells that are not lustrous like normal ones.

4. Faeces colour.

Faeces found on the feed trays should be long, glossy and corresponded to the colour of the feed being used.

5. Gill colour

The colour of the gills should be white or a very pale yellow. If gills are brown, black or red it is an indication of ill health.

6. Appendages

Legs, tail and antennae should be clean and not broken. Black marks are an indication of a bacterial infection.

7. Prawn behaviour

Prawns should not be seen swimming or schooling during the day. Schooling during the day indicates underfeeding or stress probably from the lack of sufficient algal bloom. Healthy prawns can be seen schooling around the pond at night and should avoid any light. Their eyes are a distinct red colour. Sick ones seen swimming at right angles to the pond bank, are slow in avoiding the light, often swimming away on the surface. Sick prawns' eyes are often paler in torch light, with worst affected ones showing white eyes. Note, that if prawns are swimming on the surface at night you have a low oxygen problem and this should be remedied immediately to avoid any mass fatalities.

8. Examination of soil under the check tray and soil along the pond dykes.

It is necessary to examine the soil under the check tray to assess whether or not any decomposed feed is present. If yes, then it will be necessary to use zeolite/lime for improving pond bottom condition. Also while walking around the pond it is recommended that the soil 30cm below the water level be scooped and examined at 2 or 3 places if excess black soil i.e. more than a few mm deep is prevalent. If so, it reflects deteriorating pond bottom.

3.4.8. IMPORTANCE OF KEEPING DATA

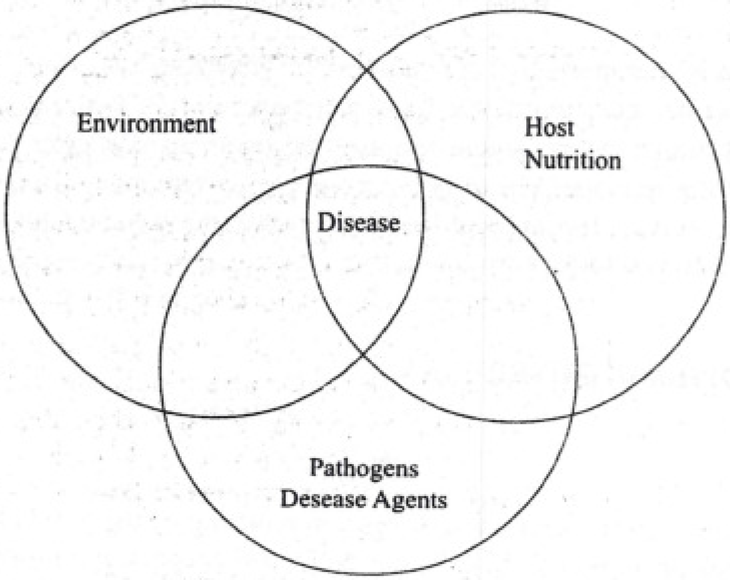
Having got a feel of feed and water management it is now necessary to identify the practical steps involved in managing ponds and the animal for obtaining consistently good production. The difference between a farmer who consistently achieves good production and a farmer who obtains erratic yields is the farmer's ability to identify symptoms of potential problems, relate them to possible causes, and take active steps to bring the pond to a good condition, and the animal to a good growth path. Water quality measurements, feed consumption trends and prawn observations taken daily are a means to enable a farmer achieve consistently good production. Prevention is better than cure needs to be operational philosophy of every prawn farmer. In prawn farming it is far easier to prevent problems than to solve them after they have occurred. Pond environment has a major role to play in the occurrence of disease and /or problems during culture. Inappropriate pond environment induces stress on the animal. Environmental stress weakens the prawn's natural immune system and its ability to resist onset of disease. The disease afflicts once the animal and/or problem can get compounded if the pond environment is not improved reducing the stress on the animal.

Keeping records together with daily observations of prawns in the pond enable quick and accurate diagnosis before any serious problems arise. Keeping record should not be viewed as an end in itself, and continuous effort will be necessary to look for meaning in the data collected by co-relating data with the behaviour and growth of the animal in the pond. It may also happen that solutions may not be found on the basis of simple observation alone. For instance, if prawns are found to have Zoothamnium on the gills and body, the usual advice and "remedy" is to treat with formalin.

3.4.9. DISEASES:

The rapid growth of the shrimp culture industry abroad has been accompanied by an increased awareness of the negative impact of disease on the industry. The development of the industry has been accompanied by the study on causes of occurrence of diseases infectious and non-infections type. The importance to be assigned to issues relating to disease is dependent on the type of culture system employed. Possibility of incidence of disease is high in semi-intensive and intensive culture systems. Except for certain types of parasitic diseases, it is the very nature of semi-intensive culture system that encourages the development and transmission of many shrimp diseases. The economic incentive for using intensive culture system dictates that disease be understood and controlled. With the experience available it is possible to undertake recognition and prevention of disease in the semi-intensive culture method.

In the development of disease on prawns as a host, three factors interact e.g. the environment, the nutrition and the pathogens. Each of these alone or two of them acting together or all three of them together can induce stress, and consequently disease.



a. The Prawn Host

The prawn body is covered by an exoskeleton, which is regularly replaced by a new one during molting. The molting process increases the energy requirement of the prawn and renders the prawn susceptible to disease agents or cannibalism. Like in human beings the prawns' immune system and resistance to disease is a function of the quality of nutrition and age or size.

b. Environment

The environment of the prawn consists of the pond soil, rearing water and the organisms in it. Dissolved oxygen, pH, temperature, light, ammonia, nitrite, etc influence the growth of organisms. All of these affect the condition of the prawn and the disease agents.

c. Disease agents

The disease agent may be a stress factor or infectious agents such as virus, bacteria, fungi and parasites which may be part of the rearing water or pond soil. Their presence and quantitative level is influenced largely by the availability of food sources, temperature, pH or dissolved oxygen. In sufficient numbers, these can readily invade injured tissues or gills of the prawn, which may eventually prove fatal particularly when the gills are blocked or when infections relating to the body as a whole or a system of bodily organs develop. If the disease agent finds the environment favourable for its multiplication or accumulation, its population or volume increases to overwhelm the defense of the host, or the stress factors weaken the host which may result in either a diseased condition, or death of the host.

d. Human factors

The human factor is all important in prawn farming. The manner by which prawns are handled during transport from the hatchery to the pond site can cause stress to the post-larvae, if not done properly. Planning and implementing sound farming management strategies consisting of proper pond preparation and water management to prevent adverse environmental conditions, quarantine during disease out break, correct feeding and feed storage, are the basic responsibilities, which depend entirely on the person who looks after the farm.

HOW TO DETECT DISEASE OUTBREAKS

Inspection

To effectively detect the early on set of disease, monitoring by the prawn farmer on the possibility of a disease outbreak in necessary. Equally important is the regular monitoring and recording of physico-chemical parameters like temperature, turbidity, water color, transparency, dissolved oxygen, salinity, H2S, ammonia pH, nitrite, checking pond-bottom conditions, feed consumption, observation on feeding trays and the conditions for feed storage. A healthy shrimp will flick its tail strongly when grasped and the tail will extend fully. During night, on using a flash light the healthy shrimp will reflect bright red eyes and they tend to swim away, whereas a diseased one reflects a pale eye colour and swims slowly. The fecal matter in the check Stray will be of dark brown or black colour in the case of healthy animals, whereas red, yellow or transparent segments in between faecal strain indicate abnormal condition.

Signs of Disease

For early detection of disease in pond, the following signs of disease can serve as guide:

Loss of appetite Empty intestinal gut/abnormal faeces
Anormal change in color Abnormal condition/color of gills
Antennular rot Lethargy
Exoskeletal rot/lesion/erosion Slow growth No molting
Physical deformity Increased exoskeletal epibionts (organisms growing on the exoskeleton or skin)
Opaque musculature Abnormally prolonged softshelling
Abnormal swimming (Swimming on surface or pond periphery) Mortalities

The following are the commonly occurring diseases observed in *Penaues monodon* culture activity.

A. Monodon Baculovirus (MBV) Disease
B. Infectious Hypodermal And Hema Topoietic Necrosis Virus (IHHNV) Disease
C. Hepatopancreatic Parvo-Like Virus (HPV) Disease.
D. Luminous Bacterial Disease
E. Shell Disease, Brown/Black spot, Black Rot/Erosion, Blisters, Necrosis of Appendages
F. Filamentous Bacterial Disease
G. Fungal Disease Larval Mycosis
H. Protozoan Diseases Protozoan Infestation
I. Microsporidiosis, White Ovaries, Microsporidian Infection
J. Gregarine disease
K. Nutritional, Toxic and Environmental Diseases Chronic Soft-Shell Syndrome, Soft-Shelling
L. Gas Bubble Disease
M. Blisters or dropsy
N. Diseases Related to Toxic Algae
O. Black Gill Disease
P. Blue Disease, Sky Blue Shrimp Disease, Blue Shell Syndrome
Q. Red Disease, Red Discoloration
R. Muscle Necrosis
S. Cramped Tails, Bent Tails, Body Cramp
T. Acid Sulfate Disease Syndrome
U. Asphyxiation, Hypoxia

Disease control depends on three factors: Prevention, Correct diagnosis and treatment. Correct diagnosis or identification of a disease is the most critical step in disease control but the key to any disease control is prevention. Prevention is better than cure should be the principle adopted by the farmer.

3.4.10. SUMMARY:

The shrimp aquaculture has developed to a great deal in recent years because of the high monetary returns. The culture of *P.monodon* is very popular in India. The first and important aspect in shrimp culture is the selection of culture practice. Depending on the type of culture practice, management practices vary. The characteristics of the three culture practices are discussed. The important aspects of shrimp culture that a farmer needs to understand such as stocking density, pond size, soils, water exchange, water depth, aeration, feeding, are explained. The general aspects of site selection for a shrimp farm and the important conditions are given. The details of the preparation of culture ponds such as ploughing, liming, water filling, fertilization are explained. The criteria for selection of prawn seed, their transportation, acclimatization and stocking are described in detail. In pond management details of the water quality parameters and biocriteria are described in detail. The water quality parameters such as temperature, salinity, dissolved oxygen, pH, turbidity and nutrients are discussed. The phytoplankton management is the most important aspect in shrimp culture ponds. The techniques of maintaining good water quality are also discussed. Feed is the single most important cost item in shrimp culture. The different types of feeds, factors influencing feed management and feeding management schemes are discussed. The importance of keeping data during the culture period is very important and its significance is explained. The shrimps are attacked by a number of diseases. The relation between the disease causing organisms, environment and host's nutrition are explained. The important diseases that occur in shrimp culture ponds are given. The importance of preventive methods in shrimp culture is emphasized, as there are no remedies for viral diseases. The need for maintenance of good water quality, hygiene and nutrition to prevent the diseases is explained.

3.4.11. MODEL QUESTIONS:

1. Write briefly about feed management in prawn culture activity.
2. Write about Pond management
3. Write a note on selection of prawn fry and transport mechanisms.
4. Write about site selection procedures for construction of prawn farms.

3.4.12. REFERENCES:

1. K.Shigeno (1978). Problems in Prawn Culture. Amerind Co. New Delhi.
2. J.E.Bardach, J.H.Ryther and William O. Mc Larney (1972). Aquaculture . The farming and husbandry of Freshwater and Marine organisms.
3. V.G.Jhingran (1982) Fish and Fisheries of India. Hindutan Pub.Co.
4. T.V.R.Pillai (1996) Aquaculture .Principles and Practices.

M. Srinivasulu Reddy

UNIT – IV

LESSON - 4.1

SEWAGE FED FISH CULTURE

4.1.1. Objective
4.1.2. Introduction.
4.1.3. Water quality parameters of the sewage water.
4.1.4. Methods of treatment
A. Mechanical
B. Chemical
C. Biological
4.1.5. Sedimentation Ponds
4.1.6. Management of sewage-fed fish culture ponds
4.1.7. Summary
4.1.8. Glossary
4.1.9. Model questions
4.1.10. Suggested reading

4.1.1. OBJECTIVE

To learn the use of sewage water for fish culture.

4.1.2. INTRODUCTION

The term sewage refers to the used water released from human habitations and industries. Sewage causes environmental degradation in view of its poor water quality with high organic load and presence of minerals. Disposal of this potentially hazardous water is of great concern to the environmentalists all over the world. In India the quantity of sewage produced per day is estimated to be around 3.6 million m3. Of this only 20.4 percent is treated in different cities in the country. Estimates indicate that about 46 million tonnes of organic matter per year can be obtained from the sewage water generated in the country. Utilization of the sewage water, after its treatment to remove the negative qualities, for use in agriculture and in aquaculture is a newly emerging area.

4.1.3. WATER QUALITY PARAMETERS OF THE SEWAGE WATER:

The liquid wastes discharged from domestic areas and industrial waste waters are referred to as sewage water contain minerals and organic matter in solution or suspension or in a dispersed state. In the sewage the component of water is about 99.9 percent while the solid dry matter contributes to 0.1 percent. The composition of the sewage generated from different sources varies in composition. Domestic sewage contains 25-40 ppm of Organic Carbon; 80-120 ppm of Total Nitrogen. The ratio between the carbon and Nitrogen in sewage waters is estimated to be around 1:3 (Klein 1962). In general, sewage waters show the following components: Nitrogen 52 ppm, Phosphorous 16 ppm, Potassium 45 ppm and biodegradable organic matter 350 ppm. Industrial effluents contain more Carbon. In the sewage water Nitrogen is present both as organically bound element and partly as

Nitrates and Nitrites. Salts of heavy metals such as Zn, Ni, Cr and Pb are recorded above permissible limits in the sewage waters. Sewage waters have high BOD (Biological Oxygen Demand). Based on the quantity of total solids present in the sewage waters they are categorized into a) strong (total solids about 1200 ppm), b) medium (total solids about 720 ppm) and c) weak (total solids about 350 ppm). Of these, nearly 69 to 72 percent are present in a dissolved state while 28 to 30 percent are present in the suspended form. Sewage waters show high specific conductivity. The strength of the sewage water is determined by the amount of 0_2 required (expressed in ppm) to oxidize the whole organic matter and ammonia present in it.

Saha et al., (1958) studied the water quality parameters of the sewage waters of the Calcutta urban conglomeration. The studies indicate the following water quality parameters: pH 6.9-7.3; dissolved oxygen- nil; C02 20-96 mg/l ; H2S 4-4-4.8; Phosphates 0.12-14.5 ppm; Nitrates 0.01 – 0.33 ppm; suspended solids 160-420 ppm. The organic matter present in the sewage starts decomposing aerobically drawing upon the dissolved Oxygen of the water, there by creating anoxic conditions. In the absence of dissolved oxygen, the organic matter undergoes anaerobic decomposition resulting in the production of gases such as Hydrogen sulfide, Methane and Carbon monoxide. These gases change into acidic form by reacting with the water and are toxic to the living organisms in the pond..

In view of the presence of high quantities of Phosphates and Nitrates the water bodies where in sewage is allowed to mix, they undergo a process of eutrophication. For utilizing the sewage in Agriculture or Aquaculture treatment of the sewage is necessary. Sewage waters contain non-pathogenic and pathogenic bacteria, but the non-pathogenic bactëria generally predominate. In the sewage water from the domestic sources the coliform bacteria load is estimated to be between 10*8 and 10*9 numbers/ 100ml.

4.1.4. METHODS OF TREATMENT:

Raw sewage is detrimental to fish in culture systems because of (a) high Biological Oxygen Demand (BOD) and Organic Carbon content (b) low Dissolved Oxygen values (c) high amounts of H_2S content in the water (d) high bacterial count and (e) high CO_2 levels. Hence, treatment of the sewage water, to remove the harmful qualities before it can be used in fish culture ponds, is necessary. By treatment of the sewage water, the undesirable qualities are eliminated and the water can be used for culture of aquatic organisms after diluting it with fresh water. The sewage water needs treatment processes for removal of the coarse suspended solids, heavy settleable solids, fine suspended solids by sedimentation, floating fats and oils by skimming, deodorization by using chlorine, ferric chloride and sterilization. The treatment of the sewage water can be carried out by the following methods.

A. MECHANICAL TREATMENT:

The sewage water is passed through screens with a small-sized mesh so that the larger sized solid materials are sieved. After filtration, the water is subject to skimming by the use of separators, to remove floating fats and oils and the fine suspended material.. This treated water after diluting with freshwater is subject again to sedimentation, when all the particulate suspended matter in the water settles down to the bottom. Releasing the sewage in to the tank at a high velocity, through a sewage channel, and a sudden drop in water velocity results in sedimentation carries out sedimentation. The supernatant clear water could be utilized in fish culture ponds.

B. CHEMICAL TREATMENT:

In the chemical treatment dissolved organic substances and the bad odours associated with the water are eliminated with the help of precipitants, coagulants and chelating agents. Coagulation and chemical precipitation, deodorization of the water followed by disinfecting or sterilization, could be used to restore the water quality to be used in culture systems. Coagulation, Precipitation, deodorization processes are carried out by the use of chlorine, ferric chloride, lime alum etc., and disinfecting by using chlorine and copper sulfate. The sewage water is also treated with chlorine and bleaching powder for the destroying the harmful organisms present in the sewage water.

C. BIOLOGICAL TREATMENT:

Biological treatment of sewage water involves the systematic use of the natural activity of the bacteria for biochemical reactions resulting in the oxidation of the organic matter into Carbon dioxide, Nitrous oxide and Sulphur dioxide. Bacteria decompose the substances either aerobically or anaerobically. Sedimentation is known to result in reduction of Biological Oxygen Demand by 33 percent, settlement of the suspended organic matter by 99 percent and reduction in albuminoid NH_3 by 23 percent (Saha 1980). By dilution with freshwater, a positive dissolved O_2 balance could be maintained. Treatment through waste stabilization ponds or sedimentation ponds is effective and easier. After the treatment, water is stored in ponds for use in aquaculture.

4.1.5. SEDIMENTATION PONDS:

The Sedimentation ponds also called the Waste stabilization ponds (Arceivala et al, 1970) and Oxidation ponds are intended for treatment of sewage water in both aerobic and anaerobic modes of stabilization of the sewage Waters. These ponds which are used in the treatment of the sewage water are also termed as Oxidation ponds by different workers (Central Public Health Engineering Institute). These ponds are either natural or artificial water bodies meant for retaining the sewage or the industrial effluent water until the wastes become stable and inoffensive for discharge into the receiving water body. These waste stabilization ponds are useful in handling small quantities of sewage water. Organic matter contained in the waste is stabilized in the pond and is converted into more stable matter, in the form of algal cells, which find their way into the effluents. Based on the biological processes taking place in the pond the waste stabilization / Sedimentation ponds are of three types:

(a) Aerobic ponds – 0.3 m in depth, with aerobic conditions. These are designed to promote the growth of algae and stabilization of wastes through microorganisms.

(b) Anaerobic ponds – 2.5 to 3.7 m depth, higher organic load, anaerobic conditions persist.

(c) Facultative ponds 0.9 – 1.5 m deep, aerobic during day as well as some time in the night. Storage of sewage water in the sedimentation pond-1 for a period of ten days, is necessary so that the organic matter is decomposed aerobically in to nitrates, phosphates, sulfur etc. The sedimentation tank-2, also called the Waste stabilization tank, receives sewage water that enters the pond from the channel at high velocity into it. In this tank it is allowed to stay for 15 to 20 days during which period the foul odour is lost and the water turns green due to the development of algal blooms. Dissolved organic mattaer is decomposed by the aerobic microorganisms resulting in the formation of Nitrates, Phosphates and Sulphates. Decomposition of the settled organic matter results in the production of Methane, Hydrogen Sulfide and Ammonia gases. Aerobic decomposition results in the algal growth, which increases the production of dissolved Oxygen that helps further oxidation. Treated sewage water in the Oxidation pond becomes clear and with nutrients and dissolved Oxygen. To remove the heavy metals the aquatic weed *Eichhornia crassipes* is grown in the pond. For an inflow of one lakh litres of sewage water, an oxidation pond of the size 50m x 20 m x 1.5 m is required.

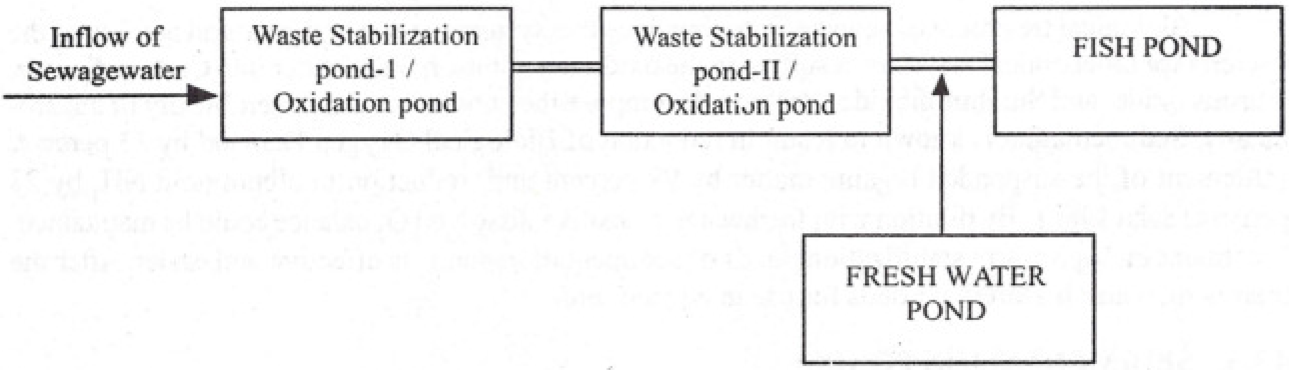


Fig. 4.1 Flow chart showing treatment of Seavage water for use in fish culture ponds.

4.1.6. MANAGEMENT OF SEWAGE-FED FISH PONDS

Water quality management in the sewage fed fish culture ponds is a very important aspect. Management of levels of dissolved Oxygen, control of algal blooms, management of the pond health and hygiene to prevent the occurrence of diseases is very crucial for the success of the culture. Usually the production ponds are of the same size as that of the Oxidation ponds, while in certain farms they are relatively larger. The nutrient rich, treated sewage water provides necessary nutrient input for the development of natural food in the pond water. Generally the stocking rates are maintained high to control the growth of algae which if not controlled will cause pollution of the pond water. The stabilized and the odourless sewage waters from treatment ponds are released, after dilution with the freshwater in the ratio of 1:5, to raise the dissolved Oxygen level and reduce the concentrations CO2, NH3, H2S at intervals of one month. The diluted sewage is supplied to the Nursery or Rearing ponds for the culture of fish. In designing the farm, the area of the fishponds to be supplied with the treated sewage should be equal to the total area of the Oxidation ponds. Phytoplankton is abundant mainly consisting of the blue green algae such as *Anabena*, *Spirulina*, *Microcystis*, green algae *Scanodesmus*, *Pediastrum*, Desmids, *Desmidium, Closterium*. Zooplankton is represented by the groups protozoa, rotifera, copepoda and cladocera.

Flow chart

In the primary and secondary ponds, fish culture can be taken up. In the stabilization pond air-breathing fishes such as *Channa spp. Anabas testudineus, Heteropneustes fossilis* and *Clarias batrachus* can be grown. In the secondary pond major carps could be grown becaues of the differences in the water quality between the first and the second stage sedimentation ponds. In the cuture experiments carried out (Kutty et al., 1979) using the effluents from the oxidation ponds and diluting it with freshwater in the proportion of 4:1 an yield of 8.44 tons per ha per annum was obtained. In sewage-fed fish culture ponds polyculture experiments using the five species of carps, Indian and exotic fish, production varied between 5.4 to 8.6 tons per ha per year. Experiments carried out by Ghosh et al., 1979 have reached a production level of 9.3 tons per hectare per annum with Tilapia from a sewage-irrigated pond. He observed that Tilapia was found to be not effected by the high ammonia nitrogen levels Akolkar and Belsare (1984) have recorded a production of 11.9 tons per ha per year in ponds supplied with sewage waters, near Bhopal. In the Oxidation ponds species like murrels can be stocked for culture. In Vidhyadah sewage-fed farm near Kolkatta in West Bengal, in the culture experiments using treated sewage water mixed with inlet water in culture ponds, a good production was obtained. The organic matter present in the sewage acts as the source for the development of nutrients. The water quality of the treated water is optimal for the growth of the carp fish resulting in better yields. Ghosh et al.,(1976) reported a production of 2.2 tons in a poly culture experiment including *Tilapia spp.* and *Clarias sp.* Harvested fish before marketing are transferred to the freshwater pond for a period of ten to fifteen days to remove the offensive odour and pathogens.

The community benefits accruing out of fish culture using treated Sewage waters are : 1. Management of the sewage water otherwise causing pollution, to production of fish 2) to utilize the organic matter as manure for the production in the fish pond and 3) to recycle water for agriculture or aquaculture.

4.1.7. SUMMARY:

Sewage from the human habitations and industries could be used in fishponds for culture of fish after proper treatment. Sewage waters contain large quantities of organic substances and minerals. In view of the presence of heavy quantities of organic matter which contributes to the nutrient level of the pond after proper treatment. Sewage waters are initially stored in waste stabilisation ponds, where the particulate matter settles down, then the clear water is stored in the oxidation ponds. From these ponds treated sewage water is diluted with the addition of freshwater in proportion 1:5 and filled in the production ponds. In view of the availability of greater amounts of nutrients in the water the plankton production is high and the fish production increases. In experiments carried out using treated water in experimental ponds using Indian and Exotic carps a production level of 5.4 to 8.6 tons per hectare is reached.

4.1.8. GLOSSARY

Biological Oxygen Demand : Also termed Biochemical Oxygen Demand,(BOD) is a measure of the amount of Oxygen required by the micro organisms to decompose the organic matter (OM) under specific set of conditions.

Eutrophication: The process taking place in a water body in which presence of excess nutrients such as Phosphates, Nitrates resulting in the excessive growth of the algal blooms. Due to the development of the algal blooms the colour of the water appears green.

4.1.9. MODEL QUESTIONS:

1.Describe the use of sewage water in fish culture ponds.

2.What is sewage Describe its water quality. Add a note on different methods of treatment of sewage water for use in fish ponds.

3. Write short note on
   a. Industrial effluents
   b. Eutrophication.
   c. Biological Oxygen Demand.

4.1.10. SUGGESTED READING:

Jhingran,V.G. 19 91 . Fish and Fisheries of India, Hindustan Publ. corp 557p.

Shammi,Q.J. and S.Bhatnagar 2002 Applied Fisheries. AgroBios (Ind). 328pp.

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UNIT – IV

LESSON - 4.2

CULTURE OF EDIBLE OYSTER

4.2.1. Objective
4.2.2. Introduction
4.2.3. Global production of oysters
4.2.4. Culture practices.
4.2.5. Natural collection of Oyster seed
4.2.6. Hatchery production of Oyster seed
4.2.7. Grow out systems and production
4.2.8. Summary
4.2.9. Glossary
4.2.10 Model questions.
4.2.11.Suggested reading

4.2.1. OBJECTIVE:

To learn about the culture practices of edible oysters

4.2.2. INTRODUCTION

Edible oysters, a group of bivalve Molluscs belong to the family Ostreidae are chiefly marine in habitat. Oysters are mainly consumed as food in sub-tropical and temperate countries such as USA, Japan, Korea, France Spain, Netherlands and Italy. Farming Oysters in the coastal waters of these countries for food, represent the earliest practices of marine Aquaculture in the world. As these bivalve mollusks are benthic sessile organisms feeding at the low trophic levels as filter feeders, their culture is a low cost enterprise.

4.2.3. GLOBAL PRODUCTION OF OYSTERS

Of the global aquaculture production, molluscs contribute to 35 percent of the production. In view of the increasing pollution of the marine coastal waters all over the world, due to indiscriminate release of the industrial effluents and sewage waters with improper treatment, and stringent import regulations on the quality of the edible oysters added by the lower demand for oysters as food in the domestic markets in the recent past, there is a marked reduction in the culture production of these bivalves. Of the cultured molluscs in coastal waters, the oysters (Family Ostreidae), mussels (Family Mytilidae and Aviculidae), clams (Family Mercenaiidae), scallops (Family Pectiniidae) abalones (Family Haliotidae) and the cockles (Family Arcidae) are commercially important. Oysters of the family Ostreidae contribute maximum to the production through culture.

The farmed oysters belong to the genera *Crassostrea* (cupped oysters) and *Ostrea* (flat oysters). In the market the flat oysters command consumer preference and fetch better price in many countries. The important species of cultivated oysters include:

Crassostrea gigas (Pacific oyster)
Crassostrea virginica (American Oyster)
Ostrea edulis (Flat oyster, European oyster)

Natural resources of edible oysters in India are represented by *Crassostrea gryphoides* , C. *discoides* C. *madrasensis* and C. *cucullata*. C. *gryphoides* and C. *discoides* are present in the creeks joining the sea in Kutch area of Gujarat state, while along Maharastra coast C. *gryphoides* is the common species. C. *madrasensis* is wider in distribution and is present along the southwest and east coast of India in all the estuaries and backwaters along the coast. C. *cucullata* called the rock oyster is distributed along the east and west coasts. The edible oyster C. *madrasensis* (Fig. 1-9a) along with the edible mussels, *Perna viridis (Fig. 1-20a)*, the green mussel, and *P .indica*, the brown mussel, are cultivated on a moderate scale along the coastal regions in India.

4.2.4. CULTURE PRACTICES:

Extensive culture methods are in vogue in many countries of the world traditionally. Commercial culture practices using extensive culture depend mostly on wild seed available in the coastal areas. The brood stocks are concentrated at certain shallow coastal areas, which provide substrate for the settlement of the spat- the egg mass. Innovative techniques in culture and methods of hatchery spawning and larva rearing are developed in recent years.

The oldest and the traditional system of oyster culture is the bottom culture. The oysters are cultured in special demarcated areas in the intertidal or subtidal zones. The method involves collection of the spat from areas of abundance in the coastal areas and transplanting them on suitable beds for on growing. In these areas for better habitat farmers need to provide empty molluscan shells at the bottom to serve as cultch for the attachment of the spat and possible reduction from parasites and predators. This production system is less productive and still continues to be practiced on a large scale because of the problems in formation of off-bottom floating structures in the coastal areas.

The second type of oyster culture system is Off- bottom culture- stake or stick culture. This is also one of the earliest practices of oyster culture, where a bamboo, or wooden or cement stakes or sticks are driven in to the bottom or arranged horizontally on racks to catch the spat. Grow out systems are in the spat- catching area itself or often in separate grow-out areas are ear marked. These types of culture systems are quite useful in intertidal areas with the soft muddy bottoms

In China, the stone –bridge method of culture is practiced for oyster culture in areas with muddy bottom. The method involves the collection of spat on cement slabs placed in the form of inverted ' V '. The seed oysters caught on the stone bridges are allowed to grow in the same areas to marketable size.

In the rack culture system, racks of different sizes and designs are used to suspend trays or strings/ ropes carrying oyster seed in the intertidal zone. They are built to about one to two meters height. String of shells with cultch is hung or placed horizontally on the racks for growing. In the suspended culture system, ropes or trays with spat are suspended from the floating rafts in the protected areas like bays. Long lines anchored at both ends and supported by floats can be laid out in more exposed areas. Trays made of wood or wire screens are suspended. To reduce the biofouling rubber or plastic coated wire mesh and polypropylene metal also are used.

Plastic mesh bags containing shell cultch are often used in certain areas for the collection of the spat. For Oyster culture, race ways, pond culture (Lee et al.,1981) and recirculating systems (Truder et al., 1977) are in use.

4.2.5. NATURAL COLLECTION OF OYSTER SEED:

Presently most of the oyster production systems depend on the spat collected in the wild. Hatchery production of seed of oysters has been developed and is practiced on a commercial scale in certain oyster farming countries.

Natural production of spat and its settlement depends on the environmental factors such as temperature and salinity. For spat collection, suitable collecting devices are used during spawning period at the proper places. Survival of the spawn is observed to be highest in the intertidal regions as it is relatively away from the predators. The time and place of spat fall is determined by a regular examination of plankton. In temporate species spawning occurs at 15-20 C during summer and in autumn and spawning takes place through out the year at higher temperature.

Different types of spat collectors are in use. They include the ones which are placed at the bottom or on raised structures. The European oyster, *Ostrea edulis* shows preference for materials containing calcium carbonate while the American Oyster , *Crassostera virginica* settles on any hard surface-wood, plastic or glass. In France and in European countries semi cylindrical ceramic roof tiles of 30 cm long and 10-12 cm diameter are used for spawn collection. In Japan and other countries the empty shells of scallops and oyster shells strung on a wire are suspended from rafts, long lines or specially constructed bamboo frames are used for spat collection.

After a month of settling when the seed oysters measure 5-10 mm in diameter, the collectors are transferred to hardening racks and laid horizontally on the platforms. The spat are exposed at least for 4 hrs at each low tide. Hardened spat is able to withstand long-distance transport and survival rate is also good.

In areas where stake or stick culture is practiced spat are generally collected on cement-dipped wooden or reinforced concrete sticks and their further growth is carried out on the same substrate.

4.2.6. HATCHERY PRODUCTION OF SEED OYSTERS

Declining natural stocks of oysters in the traditional grounds and the consequent reduction in the spat availability necessitated the development of techniques for hatchery production of seed. Hatchery technologies for spat production on commercial scale are known to be suitable for European, American, Pacific and Japanese oysters. The brood stock should contain at least 30 percent of 1.5 to 2 year old oysters as they have good percentage of males and the remaining 2.5 yr old individuals, which show preponderance of females. The brood stock is maintained in flow- through systems conditioning trays or flumes for about eight weeks during which period they are fed on algae. The fully-grown European Oyster is known to spawn spontaneously at a water temperature of 16 to 20 C. In the case of spawning of the American Oyster the ambient water temperature is raised to 25 C to 30 C for half an hour and this induce natural spawning. The release of gametes by some of the brood oysters also induces the spawning by the others. The eggs are sieved and are fertilized with the suspension of sperms in the chamber. The fertilized eggs at a concentration of 200 numbers per ml are allowed to develop with in 24hrs at a temperature of 25 C in to veliger larvae.

European Oyster, *Ostrea edulis* is larviparous and retains the eggs and larvae for a period of 7-10 days with in the mantle cavity after fertilization. Presence of piles of eggs along the shell margin of the oyster indicates the spawning. The larvae are released in swarms when they measure 170 um in size. Algal cultures of *Phaeodactylum, Dunaliella, Chlorella* are maintained to feed the growing larvae. The larvae are reared in 500 ml capacity tanks. They are stocked at the rate of 10 numbers per ml. The salinity is maintained between 25-30 ppt and the water temperature at 25 C. Algal feed from the culture tanks is supplied at a concentration of 50,000 cells per ml during the first week followed by 50,000 cells / ml during the second week and 80,000 cells/ml during the third week. During the first week the larvae are fed only ones a day while during the second and third weeks they are fed twice a day. After two weeks time the larvae of *Ostrea* sp. settle to the bottom at 24 –28 C, while that of *Crossostrea* take three weeks time for settlement on the bottom. In large tanks cleaned Oyster shells are used for settlement of the spat.

4.2.7.GROW-OUT SYSTEMS

Along the Mediterranean Coast and in France 'Hanging method of culture' is the most common practice. Ropes laden with the Oysters are suspended from wooden or metal frames in protected areas along the coast. The traditional system of growing Oysters in wide areas called "Parks' is also followed in France. In Japan suspended method of culture from rafts or long lines or racks is commonly practiced. Seed oysters are stuck to the ropes at the rate of 35-40 nos per meter length of rope. Harvesting is done by bringing down the ropes or poles after the growth period. Expected yield from each of the ropes or poles is about 5 kg.

In India for the culture of *C.madrasensis* rack culture method is followed near Tuticorin along the east coast. Each rack is 13.2 m in length and 2m in width and measures 26.5 sq.m. These racks are used for culture of marketable sized oysters.

4.2.8. SUMMARY:

Edible oysters are inhabitants of the coastal zones in the tropical and temporate areas. Mussels Clams Scallops are used as food. The oysters are cultured to augment the supply from capture fisheries in view of its demand for food. Oysters are cultured in the sea near the bottom and in the off bottom

areas. Traditionally, spat of the Oysters is collected from nature, during the spawning season and reared in the coastal waters either on the substatum or in off-bottom culture using rafts. In recent years hatchery production technology for the oyster seed is developed and is in practice. The oysters are cultured to marketable size by hanging method on ropes suspended from floating wooden or metal frames in the near coastal areas or bays.

4.2.9. GLOSSARY:

Cultch : The substrate used for the collection and settlement of the spat in oysters, usually the empty molluscan shells, plastic bags etc,. Any substrate placed in the environment to attract the attachment of oysre larvae.

Spat : The settled metamorphosed larvae present on the substratum such as rocks, molluscan shells , which form the oyster seed.

4.2.10. MODEL QUESTIONS:

1. Write an account of the culture of edible oysters.
2. Describe the hatchery production of seed and culture technology of edible oyster.
3. Write short notes on:
    a. Natural collection of spat.
    b. Oysters as food
    c. Settlement of Oyster spat

4.2.11. SUGGESTED READING :

Pillay, T.V.R. Aquaculture Principles and Practices, Fishing News Books 575pp
Bal, D.V.and K.V.Rao, 1990. Marine Fisheries of India, McGraw Hill Publ.472 pp.

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UNIT – IV

LESSON - 4.3

CULTURE OF PEARL OYSTER

4.3.1. Objective
4.3.2. Introduction
4.3.3. Structure of the shell and natural formation of pearls
4.3.4. Artificial induction of pearl formation
4.3.5. Farming of pearl oysters
4.3.6. Freshwater pearl culture
4.3.7. Summary
4.3.8. Glossary
4.3.9. Model questions
4.3.10. Suggested reading

4.3.1. OBJECTIVE:

To learn about the formation of the pearls and farming practices of pearl oysters

4.3.2. INTRODUCTION

Pearls are formed as natural concretions secreted by the mantle within the shell of the bivalve molluscs, called the Pearl Oysters. It is formed of the same material as that of the shell of a mollusc. The mantle as a protection against a foreign body usually secretes them. A pearl is formed of the nacreous substances deposited one above the other in a concentric layer laid down by the epithelium of the mantle surrounding the nucleus. It shows a central nucleus around which several layers of organic and inorganic materials are laid. The pearls are usually spherical in shape. Chemical analysis f a pearl shows the presence of $CaCo_3$ 90%, organic substances 5% and water 5%.

The pearl oyster belongs to the genus *Pinctada* of the Family Pteriidae under the class Bivalvia. hey are marine in habitat and are present in coastal waters globally. In India six species of pearl oysters of the genus *Pinctada* are recorded. *Pinctada fucata (= P. vulgaris) (Fig. 1-19b)* occurs in lare numbers contributing to the fishery and this species is considered as the pearl oyster of the Indian region. Pearl oysters occur naturally in large numbers in Gulf of Mannar in the southern tip of the peninsula. The flat rock patches lying with in 10-20m depth at a distance of 11-16 km from the shore provide a suitable substratum for the settlement of the oysters. In the Palk Bay oysters are recorded near Rameswaram at a depth of 7-13m. In the Gulf of Kutch the pearl oysters grow attached to the coral reefs. Globally, coastal areas of central America, Panama Bay, Gulf of California, coasts off Australia, Philippines and Japan support good quantities of pearl producing bivalve molluscs . The important species of pearl oysters are *Pinctada vulgaris, Pinctada margaritifera. P. chemnitzi, P. anamoides,P. atropurpurea*. Apart from the genus *Pinctada*, other bivalves that secrete pearl-like concretions of low quality are the ear shell, *Haliotes* sp. Sea mussel, *Mytilus* and Windowpane Oyster, *Placuna placenta*.

4.3.3. STRUCTURE OF THE SHELL AND NATURAL FORMATION OF PEARLS:

The shell of a bivalve mollusc is secreted by the mantle epithelium and shows the following layers formed in their shells. a)Periostracum : This is the outer most, greenish-brown, thin translucent layer made up of 'Conchiolin' an organic substance. b) Prismatic layer : This is also secreted by the mantle and is present below the periostracum. This layer is made up of the minute crystals of calcium carbonate separated by thin layers of conchiolin. The crystals are arranged perpendicular to the surface of the shell and gives strength and rigidity to the shell. c). Nacreous layer : It is called the mother of pearl and is the innermost layer of the shell. This layer is responsible for the formation of the pearl. It consists of alternate layers of calcium carbonate and conchiolin, which lie parallel to the surface of the shell. This layer is secreted by the mantle and its function is to protect the delicate surface from the harmful effects of the foreign particles.

Along with the incurrent water in to the shell of a bivalve mollusc through the inlet siphon sand grains, parasites enter and get attached to the mantle epithelium. This foreign body in due course is enclosed by the mantle epithelium, which starts secreting concentric layers of **Nacre** around it and completely encloses it. Epithelial layers secrete **Nacre** continuously which is deposited in different layers surrounding the foreign particle.

The most common view held regarding the formation of the pearl is that the pearls are formed due irritation caused to the mantle by the entry of a foreign body. It is observed that the size of the pearl formed depends on the degree of irritation caused by the foreign body.

4.3.4. ARTIFICIAL INDUCTION OF PEARL FORMATION

In view of the great market demand for pearls all over the world, pearls are produced in the pearl oysters, through artificial induction of pearl formation . The oysters are induced to form pearls by implantation of the artificial nucleus and reared over a definite period in the coastal waters and the formed pearls are being collected. This method of culture is a well-organized industry for production of pearls in countries such as Japan and France. Even in India Central Marine Fisheries Research Institute has initiated the pearl Oyster culture program with a view to culture pearls. Usually the following procedure is adapted for farming the pearl Oysters for artificial induction for pearl formation

1. Collection of pearl Oysters: Oysters are collected from the deeper areas by the divers from the oyster beds in the benthic region of the sea. These Oysters are transported to the cages erected in coastal waters. These cages are made up of metal structure and with cotton netting. The collected oysters are cleaned and kept in the cages for a period of 10 to 20 days for acclimation.

2. Preparation and Implantation of the nucleus: The preparation of the graft tissue for implantation in to the oysters is a skilled and technical process. The method adopted is after Nshikow, and is the

most efficient of all the methods followed. A piece of living tissue from the mantle is cut off from a donor oyster and is inserted together with a suitable nucleus inside the living tissue of another Oyster, called the recipient. Healthy oysters are selected for the graft tissue insertion.. A small strip of tissue from the edge of the mantle measuring 7.0 -7.5 cm in length is cut off. This piece is smoothened, cleaned and washed. This tissue is divided in to 2 to 3 cm long narrow strips and again cut in to small squares of tissue. These pieces will survive in sea water for 48 hrs at 21 C. The outer edges of the graft tissue squares are to be known because the nacre secreting cells are found only on the outer surface of the mantle. For implantation experiments well grown pearl oysters are collected from nature. For the insertion of the nucleus the oyster is fixed in a desk clamp in the position of the right valve facing upward. Mantle folds are smoothly lifted to explore the foot and the main body mass. An incision is made into the epithelium of the foot and a slender channel into the main mass. The graft tissue is placed into the channel and the nucleus is placed over the graft tissue. The bench fix is quickly removed and the Oyster shell is closed and the implanted oyster is grown in nature in cages for the formation of the pearl.

4.3.5. FARMING OF PEARL OYSTERS:

Oysters implanted with graft tissue and nuclei are transferred into the cages attached with floating rafts suspended to a depth of 2 or 3 m in the seawater for about 6 to 7 days. This period is called the recovery period. These oysters are cultured in the floating cages in the sea water till the complete development of the pearl with in the shell. During this period the oysters grow in size, feeding on the natural food entering the cage along with the seawater. The cages are arranged in large areas along the coast. The oysters are regularly examined and the dead shells are removed from the cages periodically. The pearl oysters are cultured in the cages for a period of three years. Harvesting of the pearls is done after the completion of 3-year culture period. Pearl oysters harvested from the cages in the sea. The well formed pearls in the oysters are collected from the shells. After the collection, the pearls are washed in running water and in the soap solution, graded and then marketed. Pearls are usually harvested in the months from December to February, depending on the prevailing climatic conditions in the marine coastal areas.

4.3.6. FRESHWATER PEARL CULTURE:

Certain species of fresh water bivalves occurring in natural freshwater bodies like lakes, reservoirs, rivers form small sized pearls as marine pearl oysters. They belong to the family Unionidae of the class Bivalvia. The freshwater pearl forming bivalves occurring in India belong to genera *Lamellidens* and *Parreysia* occurring in India. *Lamellidens marginalis* and *L.corrianus* and *Parreysia* are the important freshwater pearl mussels in India. As in marine pearl formation, in the freshwater mussels also the mantle secretes the pearl in response to the presence of a foreign body with in the shell cavity.

Central Institute of Freshwater Aquaculture has developed and standardized the technology for the induction of pearl formation in the common fresh water mussel, *Lamellidens marginalis*. In the pearl culture experiments, induction of the pearl formation is carried out by a) implantation of the nucleus in the space between the shell and mantle b) implantation of the graft tissue and the nucleus in the mantle tissue and c) implantation of the graft tissue and the nucleus in the gonad tissue. Shell beads are commonly used as the nucleus for the formation of the pearl.

Mussels measuring 10 cm and above from the natural habitats are used for the induction of pearl formation experiments. Nucleus along with the graft tissue is implanted carefully, in the tissues of the recipient mussel. These implanted mussels are cultured in the natural habitats in cages specially erected for them. These mussels are grown for a period of three years during which period the mussels grow and the pearl also increases in size. After harvesting the mussels the pearls are collected, cleaned, graded and marketed. The gonadal insertion method for induction of the pearl, is known to yield well formed, round, large- sized pearls.

4.3.7. SUMMARY:

Pearls are secreted by the mantle cavity in some bivalve molluscs commonly called the pearl oysters. The pearls are marine in habitat and are sedentary and benthic. The common pearl oysters belong to the genus Pinctada. In nature the pearls are formed naturally in response to the presence of a foreign body with in the mantle cavity. In artificial induction of the pearl formation,these pearl oysters are collected from the nature and are grown in cages after implatation of the graft tissue along with the nucleus. The implanted oysters are grown in cages for a three years period and are harvested. The pearls are collected cleaned, graded and marketed. Freshwater mussels of the genus *Lamalledens* are also known to form pearls similar to that of the marine pearl. The artificially inducted pearl oysters are grown in lakes or reservoirs in cages for three years after which time they are harvested. The secreted pearls are collected, graded and marketed.

4.3.8. GLOSSARY:

Nucleus: It is the focus, usually a shell bead, sorrounding which the nacre is formed by the mantle forming over lapping layers . The nucleus is implanted along with the graft tissue.

4.3.9. MODEL QUESTIONS:

1. Write an account of the artificial induction of pearl formation in the pearl oysters.
2. Describe the culture practices of pearl oysters.
3. Write Notes on:
   - A. Cage culture
   - B. Freshwater pearl culture
   - C. Pearl oysters

4.3.10. SUGGESTED READING:

Pillay, T,V.R. 1993 Aquaculture Principles and Practices Fishing Newa,575 pp.

Bal,D.V. and K.V. Rao. 198 Marine Fisheries of India

Janakiram,K. and S.D.Tripathi. 1992. A manual on freshwater pearl culture.Manual series-1 CIFA 44pp.

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